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Hospital Pharmacists' Perceptions Toward The Application of Modern Technologies in Pharmaceutical Care Services in Amman, Jordan

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A Thesis Submitted In Partial Fulfillment Of The Requirements For The Master's Degree In Pharmaceutical Sciences

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جامعة الشرق الأوسط
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تصورات الصيادلة العاملين في المستشفيات تجاه تطبيق التقنيات الحديثة في خدمات الرعاية الصيدلانية في عمان، الأردن

إعداد

فرح سامي أحمد

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قُدمت هذه الرسالة استكمالاً لمتطلبات الحصول على درجة الماجستير في العلوم الصيدلانية

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Thesis Committee Decision

This thesis, titled **"Hospital Pharmacists' Perceptions Toward The Application of Modern Technologies in Pharmaceutical Care Services in Amman, Jordan"** by researcher **Farah Sami Ahmed** and was successfully defended and approved on 26/01/2026.

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To every soul who has stood with me, who has walked this road with me, thank you for believing in me, or giving me words of inspiration—to you, thank you.

It is not my attainment, but that of all who walked together with me.

Farah Sami Ahmed

Dedication

With deepest gratitude and love, I dedicate this thesis to the pillars of my life:

to my beloved parents:

To my father, and my mother—your boundless love, tireless sacrifices, and unwavering belief in me have been the light that guided every step of this journey, you are the roots from which I draw my strength, the safe haven I return to, and the reason I dared to dream.

To my cherished siblings:

My sisters and my brothers—your words of encouragement, heartfelt advice, and constant presence have been a silent force lifting me higher than I ever thought possible.

To my dear friends:

Thank you for being beside me, for reminding me to find meaning in every challenge, and to keep going, for your unwavering support, thoughtful advice, and uplifting companionship.

Above all, I dedicate this work to the spirit of knowledge, to the relentless pursuit of truth, and to the noble path of scientific discovery.

Farah Sami Ahmed

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List of Abbreviations

Abbreviation	Full Term
AI	Artificial Intelligence
AR	Augmented Reality
CPD	Continuing Professional Development
CPD	Continuing Professional Development
DSS	Decision Support System
DOI	Diffusion of Innovations
DHI	Digital Health Innovations
DSS	Decision Support Systems
EE	Effort Expectancy
EMR	Electronic Health Records
FC	Facilitating Conditions
IPPE	Introductory Pharmacy Practice Experience
LMICs	Low- and Middle-Income Countries
MANOVA	Multivariate Analysis of Variance
MR	Mixed Reality
PE	Performance Expectancy
PEOU	Perceived Ease of Use
PU	Perceived Usefulness
SPSS	Statistical Package for the Social Sciences
TAM	Technology Acceptance Model
TPB	Theory of Planned Behavior
TRA	Theory of Reasoned Action
UTAUT	Unified Theory of Acceptance and Use of Technology
UTAUT2	Extended Unified Theory of Acceptance and Use of Technology
VR	Virtual Reality
WHO	World Health Organization
XR	Extended Reality

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Abstract

Background: The fusion between artificial intelligence and various contemporary technologies is presently revolutionizing pharmaceutical services across the globe. Nevertheless, few studies exist on hospital pharmacists' perceptions, preparedness, and factors concerning adoption in Jordan, especially in Amman, which is on the verge of implementing artificial intelligence solutions.

Objective: This study had two objectives: the first one is already clarified above, and the second objective is to investigate whether the perceived use and implementation of modern technology in pharmaceutical care services are influenced by decision-making involvement and training among hospital pharmacists in Amman, Jordan. The research proposes that hospital pharmacists in Amman, Jordan, have a perceived use and implementation of modern technology in pharmaceutical care services in relation to their decision-making involvement and training.

Methods: A descriptive analytical, cross-sectional study design was used. The study used a pre-prepared, valid, and self-administered questionnaire based on

Technology Acceptance Model (TAM) and

Unified Theory of Acceptance and Use of Technology (UTAUT) models. The study had a final sample of 84 pharmacists. The reliability study had extremely high internal consistency on the overall scale with Cronbach alpha = 0.98, as well as individual subscales, which ranged from 0.88 to 0.98. All statistics calculations, correlation, linear regression, and Multivariate Analysis of Variance(MANOVA)tests, with $\alpha = 0.05$, used Statistical Package for the Social Sciences (SPSS).

Results: Perceptions of the overall application of new technology were positive across all domains, as the mean scores of all were above the mid-point. The willingness to adopt and usage received the highest mean score (M = 4.20 ± 0.60), followed by perceptions of challenges (M = 4.15 ± 0.60) and perceptions of benefits as well as institutional and environmental support (M = 4.14 each). The Pearson product-moment correlation analysis indicated positive correlations among all eight variables (all $p < 0.01$), ranging from $r = 0.58$ to $r = 0.86$. The highest positive association was found to be the one between perceptions of impact and confidence/readiness ($r = 0.86$). The multiple regression tests indicated the significance of active involvement in a decision as a predictor of awareness, attitudes, and environmental/institutional support. The significance of training in the field of AI/Digital Health emerged as a predictor of each domain of perceptions. Training explained the highest proportion of variance in environmental/institutional support ($R^2 = 0.31$, $\beta = 0.57$). There were no differences, as suggested by the MANOVA test, across both gender and type of workplace. On the other hand, differences were seen across age groups and years of experience. The differences according to experience were seen to be favorable to pharmacists who had been practicing for six years or more, compared to the others, across awareness, adoption, and institutional and environmental perceptions. The differences according to age groups were favorable to the group of pharmacists who were currently between the ages of 30 to 39 years compared to the group of pharmacists who were above the age of 40 years.

Conclusions: Results show that the pharmacists in the hospitals of Amman were highly ready and had strong intentions to accept and implement AI and new technologies, along with strong perceptions of benefits and challenges associated with adoption. Results indicate that the perceptions associated with the adoption of the innovation are correlated and can be increased through training and active participation in the decision-making practices and processes occurring within the setting.

Keywords: Artificial intelligence; digital health; hospital pharmacists; technology adoption; TAM; UTAUT; Jordan; pharmaceutical care; readiness; institutional support.

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الملخص

يساهم الاندماج بين الذكاء الاصطناعي ومختلف التقنيات المعاصرة حالياً في إحداث ثورة في الخدمات الصيدلانية على مستوى العالم. ومع ذلك، لا تزال الدراسات المتعلقة بتصورات صيادلة المستشفيات وجاهزيتهم وعوامل تبنيهم لهذه التقنيات في الأردن محدودة، لا سيما في مدينة عمان التي تقف على أعتاب تطبيق حلول الذكاء الاصطناعي.

أهداف الدراسة: هدفت هذه الدراسة إلى تحقيق هدفين رئيسيين: الأول هو تقييم تصورات وجاهزية صيادلة المستشفيات نحو تبني التقنيات الحديثة، والثاني هو استقصاء مدى تأثر الاستخدام والتطبيق المتصور للتقنيات الحديثة في خدمات الرعاية الصيدلانية بالمشاركة في صنع القرار والتدريب بين صيادلة المستشفيات في عمان، الأردن. وتفترض الدراسة أن لدى صيادلة المستشفيات في عمان تصوراً حول استخدام وتطبيق التكنولوجيا الحديثة يرتبط بمستوى مشاركتهم في صنع القرار وتدريبهم.

المنهجية: أُستخدم تصميم وصفي تحليلي مقطعي، حيث جُمعت البيانات باستخدام استبانة ذاتية مُحكَّمة مبنية على نماذج قبول التكنولوجيا (TAM) والنظرية الموحدة لقبول واستخدام التكنولوجيا (UTAUT). شملت العينة النهائية 84 صيدليًا يعملون في مستشفيات حكومية وخاصة في مدينة عمّان. أظهرت أداة الدراسة درجة عالية جدًا من الثبات، إذ بلغ معامل كرونباخ ألفا الكلي (0.98). تم تحليل البيانات باستخدام برنامج SPSS من خلال الإحصاءات الوصفية، معامل ارتباط بيرسون، الانحدار الخطي، وتحليل التباين المتعدد(MANOVA) .

النتائج: أظهرت النتائج ارتفاعًا عامًا في تصورات الصيادلة تجاه تطبيق التقنيات الحديثة، حيث تجاوزت المتوسطات الحسابية لجميع الأبعاد نقطة الوسط. سجل بُعد الرغبة في التبني والاستخدام أعلى متوسط حسابي، تلاه بُعد التحديات المتصوَّرة ثم الدعم المؤسسي والبيئي والفوائد المتصوَّرة. كما كشفت النتائج عن وجود علاقات ارتباط إيجابية ودالة إحصائيًا بين جميع أبعاد الدراسة. وأظهرت تحليلات الانحدار أن التدريب في الذكاء الاصطناعي أو الصحة الرقمية كان متغيرًا تنبؤيًا قويًا لجميع الأبعاد،

خاصة الدعم المؤسسي والبيئي، في حين أسهمت المشاركة في صنع القرار في التنبؤ بمستويات الوعي والاتجاهات والدعم المؤسسي. كما أظهرت نتائج MANOVA عدم وجود فروق دالة تعزى للجنس أو نوع مكان العمل، مقابل وجود فروق دالة تعزى للعمر والخبرة، وكانت لصالح الصيادلة ذوي الخبرة (6 سنوات فأكثر) والفئة العمرية (30–39 سنة).

الاستنتاجات: أظهرت نتائج الدراسة أن تصورات الصيادلة تجاه التطبيق العام للتكنولوجيا الحديثة كانت إيجابية في جميع المجالات، حيث تجاوزت المتوسطات الحسابية لجميع الأبعاد نقطة المنتصف. وسجل بُعد "الرغبة في التبني والاستخدام" أعلى متوسط حسابي ($M = 4.20 \pm 0.60$)، تلاه بُعد "تصورات التحديات" (($M = 4.15 \pm 0.60$)، ثم بُعد "تصورات الفوائد" وبُعد "الدعم المؤسسي والبيئي" بمتوسط (4.14 لكل منهما). وأشار تحليل ارتباط بيرسون إلى وجود علاقات ارتباط إيجابية ودالة إحصائياً بين جميع متغيرات الدراسة الثمانية ($P>0.01$)، حيث تراوحت قيم الارتباط بين r 0.58 =و r =0.86 ووُجد أن أقوى علاقة ارتباط إيجابية كانت بين "تصورات الأثر" و"الثقة والجاهزية" r = 0.86 كما كشفت نتائج تحليل الانحدار المتعدد عن الدور الجوهري للمشاركة النشطة في صنع القرار كمتغير تنبؤي لكل من الوعي، والاتجاهات، والدعم البيئي والمؤسسي. وبرز "التدريب في مجال الذكاء الاصطناعي أو الصحة الرقمية" كمتغير تنبؤي قوي لجميع أبعاد التصورات، حيث فسر التدريب أعلى نسبة تباين في بُعد "الدعم البيئي والمؤسسي" بقيمة (.($R^2 = 0.31, \beta = 0.57$) وأظهرت نتائج اختبار (MANOVA) عدم وجود فروق ذات دلالة إحصائية تعزى لمتغير الجنس أو نوع مكان العمل. في المقابل، وُجدت فروق دالة إحصائياً تعزى لفئات العمر وسنوات الخبرة؛ حيث كانت الفروق المرتبطة بالخبرة لصالح الصيادلة ذوي الخبرة (6 سنوات فأكثر) في مجالات الوعي والتبني والتصورات المؤسسية والبيئية، بينما كانت الفروق العمرية لصالح الفئة (30 إلى 39 سنة) مقارنة بالفئة التي تجاوزت 40 عاماً.

الكلمات المفتاحية: الذكاء الاصطناعي؛ الصحة الرقمية؛ الصيادلة؛ المستشفيات؛ تبنّي التكنولوجيا؛ الخدمات الصيدلانية؛ الأردن؛ الاستعداد؛ الدعم المؤسسي.

Chapter One

Background and Problem Statement

1.1 Introduction

The relentless progression of modern technologies has led to a revolution in health care systems and, specifically, to the model of pharmaceutical care delivery. Artificial Intelligence(AI)-based technologies are now used to perform real-time clinical data analysis, create personalized therapy plans, and offer predictive decision support, which results in enhanced patient outcomes and operational efficiencies (Rowe et al., 2024).In the field of pharmacy practice, AI has been identified as a revolutionary force capable of assisting with automated dispensing of medications, the identification of drug interactions, and the development of tele-pharmacy and remote-care technologies (Awala & Olutimehin, 2024).

Machine learning and natural language processing-based artificial intelligence have become common assistive devices in hospital practice. However, much more than this, pharmacists are now using other machine learning or artificial intelligence assisted systems for their clinical as well as administrative tasks. However, as the front-liners of medication, their technology adoption in terms of awareness, use, and acceptance of such artificial intelligence plays a major role for medication or their use of artificial intelligence in medication management (Venkatesh et al., 2003).

A number of studies have already revealed that pharmacists' and pharmacy students' attitudes towards using AI is diverse and varies, according to their education and knowledge, previous experience, and perceived value of such tools (Hasan et al., 2024). For this reason, the study of pharmacists' perceptions of AI is of high importance,

since it can provide crucial information regarding the digital transformation's guidance for increasing the efficiency and quality of pharmaceutical care services

1.2 Purpose of the Study

1. To determine pharmacists perceived use of modern technologies in pharmaceutical care services.
2. To determine the benefits and limitations that pharmacists perceive are associated with the use of AI technologies.
3. To determine how prepared pharmacists are to use and borrow AI tools in practice.
4. To provide recommendations that could ensure better uptake of AI in apothecaries based on the views of pharmacists.

1.3 Significance of the Study

The main contribution of this study is in closing the gap of the literature in the field of digital transformation of the pharmacy sector by generating empirically-based evidence from the country context in which the use of AI is in an early stage of development. The outcomes of the above research will be able to clarify the way in which pharmacists react to the next generation of technology and systems, as well as the conditions that may possibly affect the readiness of the pharmacists to adopt them. Furthermore, the information will be used to create a foundation for the design of training, policy, and guidance, as well as the strategy for the use of AI in the practice of pharmacy in hospitals, using the data collected based on the outcomes (Raza et al., 2022).

Second, through an examination of pharmacists' views, this research can improve aligning AI implementation with pharmacists' needs and priorities. This can facilitate an effective use of AI solutions for good and according to pharmacists' values, practices, and role (Bohr & Memarzadeh, 2020). This research can also facilitate improvements in pharmacists' tele-pharmacy and remote healthcare delivery services. This is because these services have increased their relevance with the advent of the coronavirus outbreak (Awala & Olutimehin, 2024). In summary, this research can bridge an imperative gap which currently exists in research conducted on AI and the Arab world, and specifically on healthcare. It also contributes to the efforts to modernize and advance pharmaceutical care in the region in line with global digital-health trends.

1.4 Research Questions and Hypotheses:

RQ1. What are pharmacists' attitudes towards the deployment of modern technologies such as artificial intelligence (AI) in pharmaceutical care services?

RQ2. Do pharmacists' attitudes towards AI technologies significantly differ according to demographic characteristics (age, years of experience, and workplace)?

RQ3. What are the perceived advantages and obstacles to implementing AI technologies in pharmacists' clinical practice?

RQ4. To what extent do pharmacists embrace and utilize modern technology tools, particularly AI, in pharmacy practice?

RQ5. How do perceived ease of use and perceived usefulness of AI technologies influence pharmacists' willingness to adopt them in pharmaceutical care services?

Research Hypotheses:

H_1: Pharmacists tend to have a favorable attitude towards applying AI technologies in pharmaceutical care services.

H_2: Pharmacists' attitudes towards AI technologies significantly vary according to demographic variables (age, years of experience, and workplace).

H_3: Pharmacists who have prior experience with AI technologies are more open to applying AI tools in pharmacy practice than those without such experience.

H_4: Perceived ease of use and perceived usefulness of AI technologies significantly influence pharmacists' willingness to adopt them in pharmaceutical care services.

1.5 Study Scope

- **Geographical Scope:** This study was undertaken at public and private hospitals in Amman, Jordan. Jordan's capital city Amman is the central hub for healthcare and pharmaceutical practice in the country. It is home to the largest and most important public and private hospitals and pharmacy departments that have already begun adopting Digital Health Innovations (DHI) solutions, including AI-enabled apps and devices. The environment enables interaction with experienced pharmacists as well as valuable perspectives on the onset of AI implementation.
- **Temporal scope:** This project was conducted place in the second half of the year 2025.

- **Subject Scope:** The study focuses on the hospital pharmacists working in the Jordanian city of Amman and their perception and attitudes towards the use of Artificial Intelligence in the pharmacy practice.
- **Topical Scope:** This includes pharmacists' awareness, adoption, and perceptions of benefits and difficulties associated with the use of AI technology, besides the effects of demographic variables. In this context, the research shall refrain from exploring the technological part of the use of AI.

1.6 Study Definitions

In this section are the conceptual and operational definitions of study terms.

1. **Artificial Intelligence (AI)**

- **Conceptual Definition:** Artificial Intelligence is the ability of a computer program or machine to think and work like a human by imitating human intelligence processes including learning, reasoning, problem-solving, perception, and use of languages (Bohr & Memarzadeh, 2020). In the health context, Artificial Intelligence applications include machine learning, deep learning, and natural language processing, which support clinical and administrative activities in healthcare.
- **Operational Definition:** Artificial Intelligence for this study is the digital or computer software used in hospital pharmacies to support the management of medications, validation of prescriptions, and clinical decision support, and personalization of treatment plans from the pharmacist’s perspective.

2. **Pharmaceutical Care Services**

- **Conceptual Definition:** Pharmaceutical care is the appropriate provision of drug therapy for the realization of certain achievable outcomes in the life of a patient in order to improve his quality of life (Raza et al., 2022). It also involves counseling of patients, medication review, surveillance for drug-related problems, and providing individualized drug therapy plans.
- **Operational Definition:** For the purpose of this study, pharmaceutical care services will be defined as any clinical or counseling activities practiced by hospital pharmacists, where an artificial intelligence application could be introduced or is already being practiced to improve care quality and efficiency.

3. **Pharmacists' Perceptions**

   - **Conceptual Definition:** Perception is the way in which an individual is aware of and understands a concept and is influenced by an individual's previous experiences, knowledge, and attitudes (Rowe et al., 2024).
   - **Operational Definition:** Pharmacists' perceptions will be measured with a questionnaire to gather their level of awareness, attitudes, acceptance, and concerns toward the use of AI in pharmaceutical care.

4. **Acceptance of AI**

   - **Conceptual Definition:** Acceptance of AI indicates the degree of pharmacists' agreement or willingness to use and incorporate AI tools into their practice. It is often conceptualized based on the theory of perceived usefulness and ease of use. (Syed et al., 2023).
   - **Operational Definition:** Acceptance will be determined by the pharmacists' response on a Likert scale to the question measuring their willingness to use AI tools in their work and their perception of the professional value of AI.

5. **Perceived Benefits and Challenges**

   - **Conceptual Definition:** Perceived benefits are the potential positive aspects pharmacists recognize in AI such as accuracy, efficiency, and patient safety. Perceived challenges are the potential negative aspects such as job replacement fears, data privacy concerns, or lack of training (Awala & Olutimehin, 2024; Hasan et al., 2024).
   - **Operational Definition:** Perceived benefits and challenges are assessed through survey items that ask participants to rate their agreement with statements related to the benefits and barriers of AI implementation in pharmacy practice.

1.7 Conceptual Framework

The conceptual framework for this study is built on three existing and prominent technology adoption models: Technology Acceptance Model (TAM) (Davis, 1989), Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al.,2003), and Diffusion of Innovations Theory (Rogers, 2003). These models in common assume that successful innovation adoption is a result of users' exposure and experiences to technology, awareness and perceptions, perceived benefits and barriers to use and overall intention to adopt factors that are ultimately affected by contextual and demographic factors. Combining the three theories allowed for incorporation of both individual level technology adoption (TAM and UTAUT) and system level diffusion (Rogers' theory).

Inspired by the literature review, the model that has been presented as in Fig. 1 is that the exposure to AI and other technologies through learning, working, or self-learning experiences, which is the primary independent variable, is expected to have a direct impact on hospital pharmacists' knowledge, attitude, and perception on the benefits and barriers of AI for pharmaceutical care. The knowledge, attitude, and perception are proposed to be the mediators for the relationship between exposure and their willingness to use AI-based applications. Absorption, which is the expected end, or the final independent variable of the model, is the sustained and practical application of the AI technologies.

Demographic characteristics (e.g., age, gender, years of experience, educational level and prior digital-health training) can be viewed as moderators in these relationships, which are likely to enhance or suppress them. For example, we would expect prior experience or training to increase awareness and adoption and limit experience to increase the salience of complexity or resistance to change.

In summary, the developed theoretical model incorporates elements of global, regional, and local evidence to represent the process through which Jordanian hospital pharmacists are expected to move from their exposure to AI, through the cognitive and attitudinal processes and towards behavioral adoption and use-integration. The model effectively operationalizes the theoretical components of TAM, UTAUT, and Diffusion of Innovations theory in the Jordanian healthcare context and serves as a structured foundation for empirical testing of the expected relationships between the constructs of exposure, perceptions, willingness to use, and absorption.

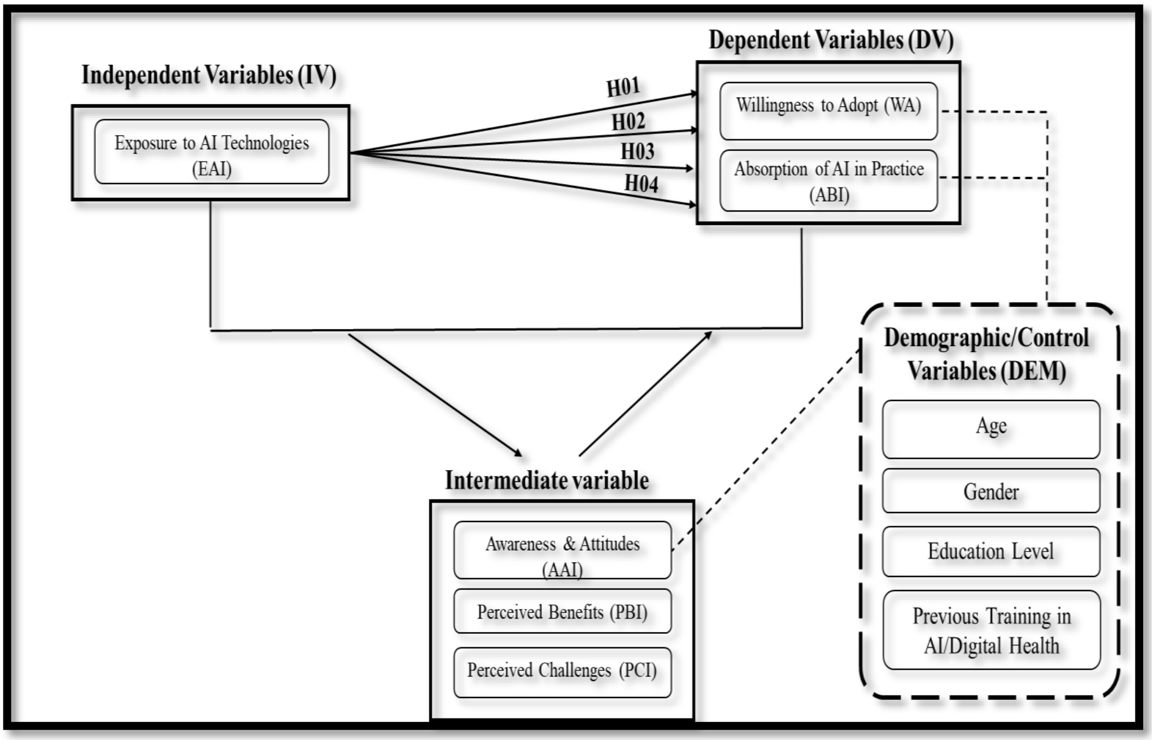

Figure3.1:Conceptual Framework of the Study: Linking Exposure to AI,Pharmacists' Perceptions, Willingness to Adopt, and Absorption, with Demographic Moderators

Chapter Two
Theoretical Literature and Previous Studies

2.1 Theoretical Foundations of Technology Adoption in Healthcare

We relied on three prominent models to aid us in understanding the implications of the results for how pharmacists can respond to the new technology, to provide us with a clear understanding of our research: The Technology Acceptance Model (TAM), The Unified Theory of Acceptance and Use of Technology (UTAUT), and Rogers' Diffusion of Innovations theory. According to the technology acceptance theory, the use of the technology by an individual will be influenced by their perception regarding the value for money and the ease of use of the technology. The UTAUT, on the other hand, proposed an extended version of this theory and included three constructs: performance expectancy, effort expectancy, social influence, and facilitating factors. The theory of Diffusion of Innovation proposed by Roger may as well support the proposed study, which works as the means to adopt the new technology. DOI lists five stages of technology adoption, including awareness, interest, evaluation, trial, and adoption. These theoretical models will be applied to understand pharmacists' acceptance and use of artificial intelligence (AI), virtual reality (VR), augmented reality (AR), and mixed reality (MR) technologies in their pharmaceutical care.

2.1.1 Technology Acceptance Model (TAM)

The TAM was created by Davis (1989) and since then it is one of the most frequently used and cited theories about individuals' adoption of new technologies. The TAM suggests that Perceived Usefulness (PU) or "the belief that using a technology will improve job performance" and Perceived Ease of Use (PEOU) or "the belief that the technology is effortless to use" (Chuttur, 2018) create users' attitude, which finally results in their actual usage.

As depicted in Figure 2.1, user's perception, which is an outcome of system design characteristics, will result in an attitude as well as behavioral intention to adopt a technology. Therefore, both are equally important.

Later expansions like TAM2 (Venkatesh & Davis, 2000) and TAM3 (Venkatesh & Bala, 2008) added more components, such as social influence and facilitating conditions.

In healthcare, TAM has been applied extensively to understand healthcare professionals' adoption of electronic health records(EMR), telemedicine systems, and AI-based tools (Holden & Karsh, 2010). In pharmacy, it has been found to successfully explain pharmacists' willingness to adopt various tools, such as e-prescribing and medication management software. In such cases, usefulness and ease of integration are good predictors of tool adoption (King et al., 2022; Hasan et al., 2024).

Therefore, TAM is an appropriate basis for the current study because it explains the influence of Jordanian hospital pharmacists' perceptions of usefulness and ease of use on their willingness to use new modern technologies in pharmaceutical care.

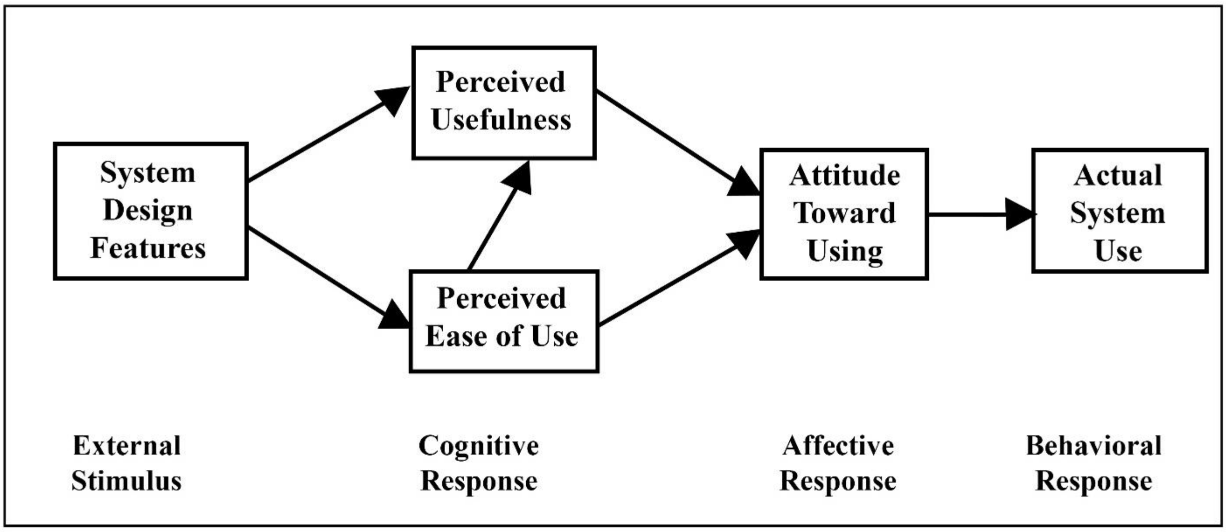

Figure 2.1: Technology Acceptance Model (TAM) (Adapted from Davis, 1989)

2.1.2 Unified Theory of Acceptance and Use of Technology (UTAUT)

The (UTAUT) is a model created by Venkatesh et al. in 2003 and it is a synthesis of eight earlier adoption theories (these theories are the Technology Acceptance Model (TAM), the Theory of Reasoned Action (TRA), the Theory of Planned Behavior (TPB), the Diffusion of Innovations, the Theory of Interpersonal Behavior (TIB), the Motivational Model (MM), the Model of PC Utilization (MPCU), and the Social Cognitive Theory (SCT)). It was a response to the adoption of several models, which looked at slightly different determinants of use and had low explanatory power individually. UTAUT was developed by aggregating the determinants which showed strongest associations in the past literature into one model that explains the majority of the variance.

As shown in Figure 2.3, UTAUT model specifies four core constructs which are Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI) and Facilitating Conditions (FC). These four factors in terms correspond to perceived usefulness, perceived ease of use, social influence, and facilitating conditions. The effect of these core constructs on behavioral intention and actual use were influenced by the moderating constructs of age, gender, and experience (Venkatesh et al., 2003).

Later additions, most significantly UTAUT2 (Venkatesh, Thong & Xu, 2012), added hedonic motivation, price value and habit further increasing its use in consumer and health-care contexts (Alalwan, Dwivedi & Rana, 2017). UTAUT has been used in health-care research to understand the use of telemedicine systems and clinical decision-support systems by health-care professionals. Performance and effort expectancy have been found to be consistent predictors of actual use in these studies (Chang et al., 2007; Alalwan et al., 2017).

Consequently, the proposed model is applicable to this study because it aims to explain the impact of Jordanian hospital pharmacists' beliefs about usefulness, ease, social influence, and institutional support on their intention to use AI and other digital applications in pharmaceutical care.

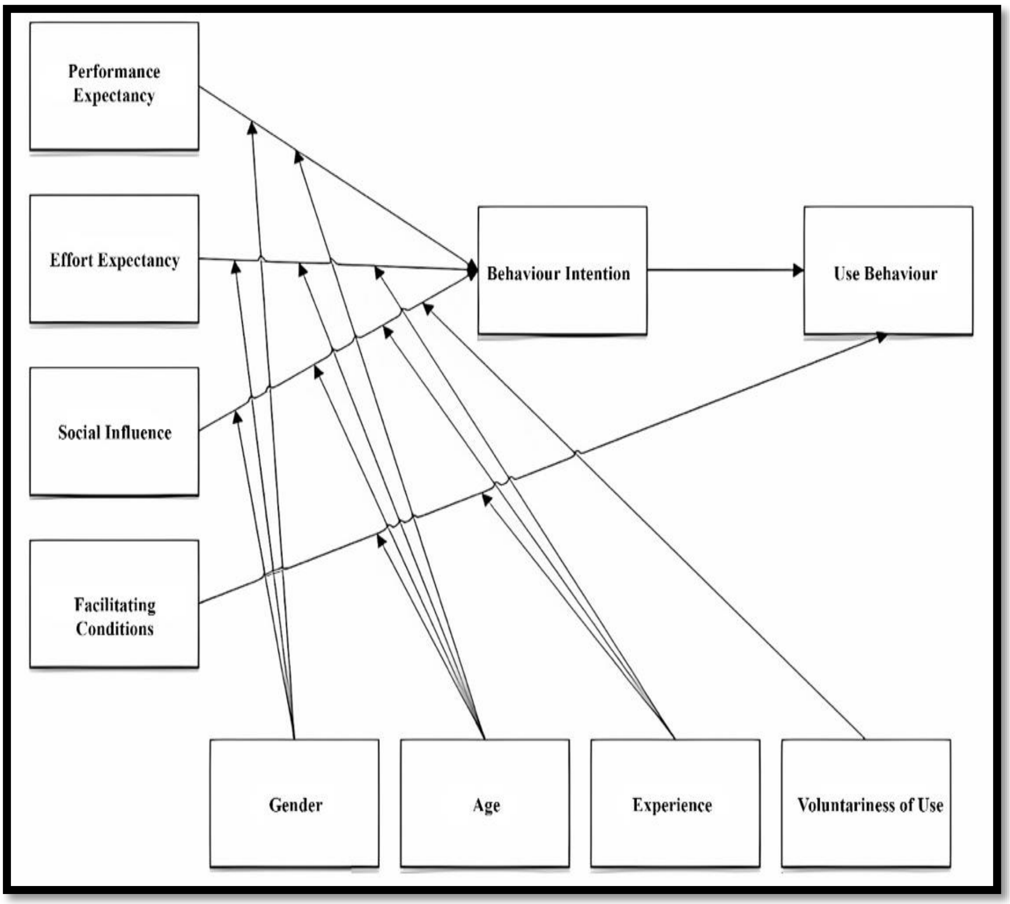

Figure 2.2: Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003)

2.1.3 Diffusion of Innovations (Rogers)

The Diffusion of Innovations (DOI) is a theory by Everett Rogers (1962; 2003) that tries to explain how new ideas and practices are adopted by members of a social system over time. The process of diffusion takes place when an innovation is communicated through certain channels among the members of a community; therefore, the adoption of innovation is perceived as a gradual process determined by the communication process, social rules, and the innovation's perceived properties.

Rogers identified five adopter categories: innovators, early adopters, early majority, late majority and laggards. In sequence, these form the widely known S-shaped curve of adoption, demonstrating the process of change and innovation from early adoption to final implementation. The speed of adoption was related to five perceived attributes of an innovation: relative advantage, compatibility, complexity, trialability, and observability which helped to determine whether a technology was adopted or rejected.

DOI has also been applied in the healthcare and pharmacy sectors to analyze the diffusion of digital tools. This includes electronic health records, telemedicine, and AI-based systems. The theory highlights that adoption is contingent not just on the perceived superiority of the technology but also on the organization's readiness and the culture of the professional group. In these settings, early adopters, such as digitally savvy pharmacists, can become change agents, shaping the acceptance of new tools among their peers.

DOI can help in the current study by providing an explanation of the relationship between the Jordanian hospital pharmacists' perceptions of attributes of innovation and their intentions towards the adoption of innovative technologies, such as AI, VR, AR, and MR, for pharmaceutical care purposes.

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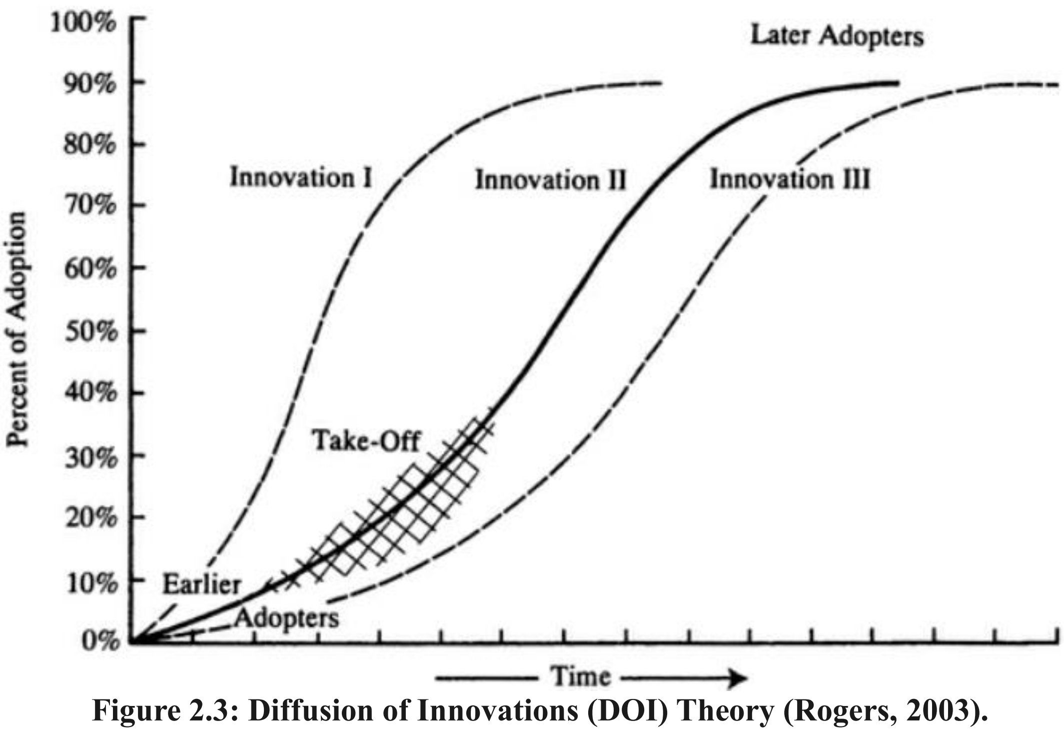

Figure 2.3: Diffusion of Innovations (DOI) Theory (Rogers, 2003).

2.1.4 Integration of Theories: Toward a Comprehensive Understanding of Technology Adoption in Healthcare

(TAM) Unified Theory of Acceptance and UTDI are similar but with subtle differences. Healthcare professional's adoption of innovation can be better understood by integrating the three.

TAM focuses on the individual's perceptions of usefulness and ease of use as determinants of adoption, whereas UTAUT expands on this by also considering the roles of social influence and facilitating conditions. DOI contextualizes these individual factors within a broader social framework, particularly highlighting the roles of adopter categories and innovation attributes like relative advantage, compatibility, and complexity.

The combination of these two theories provides a means to measure personal and institutional factors of adoption and how they are all interconnected. It can also be used to correlate users' attitudes and intentions to use e-pharmacy services with that of institutional readiness and technology diffusion. This combination, it can be applied to a situation such as the adoption of e-pharmacy in Jordanian practice as the success of such process will not be assured unless it matches with pharmacists' perceptions and the presence of organizational resources and training programs for these staff. This, as such, provides a solid theoretical underpinning of the study to explore hospital pharmacists' readiness for adopting the use of technologies in pharmaceutical care.

2.2 Modern Technologies in Pharmaceutical Care

Artificial Intelligence (AI) and extended-reality (XR) technologies, such as Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR), are driving the rapid digitalization of the global pharmaceutical sector. The teaching and application of pharmacy practice have been revolutionized through immersive learning experiences for training pharmacists. Despite the increased awareness of such technologies, the application of technologies such as AI is hindered by a lack of relevant training or readiness. Rowe et al. (2024) found a lack of confidence among pharmacists despite being aware of AI's potential for optimizing the efficiency of their practice as well as the safety of patients. In a similar study conducted by Rowe et al. (2024) among pharmacists and pharmacy students enrolled in institutions of learning located in Jordan, Lebanon, and

Libya, Hasan et al. (2024) found a lack of experience with AI. The study indicates a possible intervention strategy through designing a modelled framework for such training. Syed et al. (2023) pointed out the existence of a problem of an “attitude-competence gap” with regard to the application of AI as a related technology among health science students of the Kingdom of Saudi Arabia. In the same vein, the uptake of AI by tele pharmacy was described by Raza et al. (2022) as being dependent on a conducive environment, appropriate guidance on training and use, and confidence in using AI. A similar description has been given for the uptake of AI in clinical pharmacy services by Awala and Olutimehin (2024).

When it comes to the potential for VR to improve competence in pharmacy education, there is some evidence that VR can close the gap between the classroom and the pharmacy or hospital. For example, a quasi-experimental study by Alkhudair et al. (2024) in Saudi Arabia found that Pharmacy students trained through a virtual reality-based simulation of hospital and counseling settings performed better, reported higher satisfaction, and felt more confident compared to those receiving traditional didactic teaching. A systematic review by Beshir et al. (2022) concluded that across all their selected studies, virtual-patient simulations had better learn outcomes compared to traditional teaching methods in terms of decision-making skills and knowledge retention. Zhou (2023) provided evidence from China in the form of a browser/server-based VR system that was able to accurately simulate and teach the pharmaceutical manufacturing and compounding process without posing the same safety risks and operation costs in real life. The increased use of experiential learning for students was also possible with the system.

AR learning tools can be used to augment physical environments with virtual elements. They have been found to be effective for lab work and skill learning as well. Kapp et al. (2022) found that AR smart glasses and mobile devices increased student motivation and procedural accuracy in Finnish pharmacy laboratories. Albrecht et al. (2013) demonstrated in Australia that AR learning modules increased both recall and engagement compared to learning from textbooks. Kurniawan et al. (2022) created the ARx mobile application for compounding laboratories that 90% of students preferred to traditional methods due to the design of the application that allowed for more interactivity and autonomous learning.

Positive perceptions of AR among pharmacy students in Hong Kong were found by Li, Ng and Lee (2021), who still faced certain technical challenges, including device incompatibility. Babatunde et al. (2023) in resource-constrained settings recommended the implementation of AR and gamified learning in pharmacy education in Africa due to their low-cost, scalability, and ability to increase student engagement.

Mixed Reality (MR), the integration of VR and AR, may offer the best of both worlds, allowing students to interact with virtual objects in real time within their physical surroundings. Takemoto et al. (2019) concluded that MR would prove useful in improving the implementation of experiential learning in simulation education because it would develop more realistic simulations of the clinical environments and scenarios. Another study done by Moro et al. (2021) found that MR would prove to be a successful technique in improving the perception of space and the retention of medical anatomy skills in the long run, which would be easy to transfer to pharmacy education to enable the students to have a better understanding of the drug mechanisms and molecular structures. As MR technology remains in the early stages of its adoption in pharmacy education, there are a number of limitations that MR technology might have the capacity to tackle. This would include the lack of availability of laboratory space in the current pharmacy education modalities. Moreover, there would also remain the lack of the needed components to develop a safe working environment. Another limitation would include the costs associated with the acquisition of the technology.

Some other studies show that the willingness to implement the AI systems alone would possibly be inadequate to reap the benefits of the implementation process. In Jordan, for instance, both Hasan et al. (2024) and Jarab et al. (2023) discovered positive general attitudes of pharmacists towards AI while also noting several remaining barriers to actual adoption and practice, such as lack of digital infrastructure and training, as well as high costs of the AI software solutions. The same conclusion has been drawn by Syed et al. (2023) and Raza et al. (2022), who determined that despite the growing awareness of AI, its adoption in pharmacy often stays superficial unless there is an organised institutional approach to its support and ongoing capacity building. In light of that, necessary actions could include national policy reform, professional development, and updates to the educational curricula.

Jordan, however, appears to be not as far in the advancement of AI, VR, AR, and MR technologies in the education of pharmacists and their practice. Jordan's approach is characterized by its conventional methods and the extensive use of traditional teaching models in teaching and training of students with little to no major investment in simulation and practical training technologies and limited integration of digital tools and infrastructure. In addition, other barriers, such as limited financial and physical resources, and the lack of a national strategy (Alsharif & Nguyen, 2021; Jarab et al., 2023) are factors to the late transformation towards new technologies. On the other hand, the Gulf region, for instance, the Saudi and Emirati pharmaceutical sectors, have made efforts in the development and implementation of transparent and direct funding mechanisms and regulatory structures that have supported educational facilities in the movement to digitization of different levels of learning. The case of Jordan is different; with no clear national guidelines for technological integration, Jordanian pharmacy schools remain in need of clear direction and national policy coordination for them to be digitally ready for their future graduates to work in a Predictive, Preventive, Personalized, and Participatory healthcare system supported by advanced digital technologies and artificial intelligence.

2.3 Pharmacists' Awareness, Attitudes, and Perceptions

Awareness, attitude, and perception are the foundation on which pharmacists make decisions about providing safe and progressive pharmaceutical care. Nevertheless, existing evidence suggests a high level of inconsistency across different settings. In Egypt, Bashir et al. (2020) showed that while the majority of community pharmacists were aware of the risks of counterfeit medicines, many of them were not very accurate in their understanding of detection strategies and regulations and they generally relied on their own personal judgment rather than formal training. A similar situation has been seen in the Iranian market. In this situation, the limited awareness of existing supply chain controls has led to the distribution of counterfeit drugs.

Regarding the general public, it was found that the general awareness of services such as medication review, disease surveillance, as well as vaccinations is low. The concept of such services was known by them generally, though the details regarding the associated processes and evidence-based advantages were found to be less uniform, as pointed out by Ababneh et al. (2023). As per advanced clinical services such as medication reconciliation, patient counseling, and other services provided to patients, it was found that the general awareness of such services is not wide-spread.

It is worth mentioning that pharmacists have been shown to have favorable views towards the development of their clinical role and the utilization of modern technologies (Ababneh et al., 2023; Hasan et al., 2024). Indeed, investigations conducted in Malaysia, Jamaica, and Jordan have revealed that pharmacists are very enthusiastic about patient-centered pharmacy services like health promotion and smoking cessation programs, although they are limited by time and lack of skills and facilities (Ababneh et al., 2023). In fact, Hasan et al. (2024) have obtained similar opinions: Saudi Arabian, Lebanese, and Jordanian pharmacists have favorable views towards implementing AI-assisted decision support system(DSS)systems in practice, although their implementation is limited by financial and organizational factors.

Practice is also further informed by perceived professional identity. Pharmacists in developed healthcare systems see themselves as members of the teams caring for patients, while this role is much less common in the developing world (Ababneh et al., 2023). Jordanian pharmacists recognize the significance of technology and service expansion; however, their professional contributions remain limited by structural and financial barriers.

2.4 Global Evidence on Pharmacists' Perceptions

Internationally, a pharmacist's scope of practice has been debated to include a broader patient-centered approach or a narrow, more traditional image focused on dispensing. One study on this patient-centered focus suggested that the profession has been historically limited by public portrayals in the media. An American study found that, between 1970 and 2013, the attitude of the media towards pharmacists was negative, and the Polish and Saudi Arabian surveys found that the public retains a outdated view of the pharmacist as a dispenser versus a team player in the clinic. A lack of public awareness about the pharmacist's role in patient care was further identified in other countries, such as New Zealand.

As far as pharmacists are concerned, it is possible that perceived clinical importance may not match with priorities based on evidence. Loewen, Merrett, and De Lemos (2010), in their study in Canada, observed that a considerable amount of time was spent by hospital pharmacists on activities that they perceived to be most important, though these may not be so important from the evidence-based viewpoint. Activities like taking patients' medication history and drug information counseling, which had been demonstrated to be of clinical value, received lower importance. Further, a recent global evaluation of professional values among pharmacists (Ababneh et al. 2023), undertaken in 26 countries, highlighted that despite their appreciation of the perceived importance of expanded roles such as medication review, vaccination, and smoking cessation counseling, pharmacists actually struggled with these due to the influence of time, workforce, cooperation gaps, and training.

Results from a survey conducted by Ababneh et al. (2023) among community pharmacists in Jordan, Saudi Arabia, and other regional countries reported a positive attitude and interest among the respondents towards cancer awareness and medication reconciliation. However, lack of training resources and institutional support were observed to act as potential hurdles to the efficient delivery of these services. Another survey study published by Ababneh, Halwani, and Alshehri (2023), specifically focusing on the context of Jordan, reported that pharmacists are involved in community activities such as breast cancer awareness programs and smoking cessation initiatives. However, there are hurdles to this practice, such as lack of time, lack of demand from patients for such activities, among others. The study published by Hasan, Jarab, and Salameh (2024), aimed to determine the attitudes of pharmacists on the application of artificial intelligence technologies for decision support in their practice. The study was conducted in Jordan, Lebanon, and Saudi Arabia. The result observed that there is a positive attitude among the pharmacists on the application of such technologies in their practice. However, there are hurdles to the application of such technologies, such as training needs. The collective insights from these studies highlight a profession open to innovation and new roles, yet systemic challenges in policy, resources, and professional development hinder the translation of these attitudes into widespread practice changes.

2.5 Status of AI and Digital Transformation in Jordanian Pharmacy

Artificial Intelligence (AI) application to pharmacy practice in Jordan is still at its infancy stage of development and integration. The current state of practice can best be described as consisting of a few pilot projects, academic ventures and very limited implementations at a hospital level, but have not yet achieved nation-wide adoption. A digital transformation national policy (REACH2025) has been set in place in Jordan and identified healthcare/pharmaceuticals as one of the main sectors to be targeted for digitization with gradual application of artificial intelligence, big data and machine learning for use in clinical decision-making and optimization of supply chain management (Adaileh & Alshawawreh, 2021). However, real-life implementations in hospital pharmacies are still piecemeal and to date has been primarily automated dispensing, e-prescribing and some nascent clinical decision-support modules.

Available research on the subject, based on empirical data, has shown that Jordanian pharmacists show awareness and interest in the use of artificial intelligence, however, they lack the necessary training and institutional framework. A recent study conducted by Hasan, Jarab, and Salameh (2024) showed that pharmacists from Jordan and other surrounding countries had a positive perception of artificial intelligence and its use in pharmacy practice with the expectation of being more efficient and to ensure patient safety. However, their use of AI was described as being at a superficial level, which could be attributed to lack of exposure and limited digital infrastructure. The research by Alsharif and Nguyen (2021) showed that despite Jordan's investment in pharmacy education, traditional didactic instruction remains the main form of teaching and there was limited use of simulation or AI-augmented learning tools, and this was reported to affect pharmacy graduates' preparedness to practice in an environment that heavily relies on technology. Furthermore, AI was adopted by some hospitals in Amman in the form of drug-interaction check modules and electronic inventory management, although it is mostly used at a tertiary level. In community settings, the use of tele-pharmacy services is an emerging form of AI but is also faced with challenges on a regulatory and infrastructural level. The World Health Organization (2021) has provided recommendations, stating that it is necessary to first put in place the necessary regulatory and ethical framework for AI, along with developing the workforce and equipping them with the necessary skills to use it, before its widespread adoption in low- and middle-income countries (LMICs) such as Jordan.

Vacuum in education, training, and professional development is also a concern. In an international study, it was found that while over 90% of Jordanian pharmacy students and faculty were aware of AI, less than 40% had a clear understanding of the basic concepts, and less than 20% had formal training on the topic (Hasan et al., 2024). In another study, Odeh et al. (2021) found that less than 20% of pharmacists in hospital and community settings had access to formal programs on digital competency or leadership development. Lack of such opportunities has led many pharmacists to acquire digital skills and leadership abilities informally by trial and error, as opposed to formal continuing education. Incidentally, recent evidence indicates that there may also be an emerging trend of generative AI applications like ChatGPT use among pharmacists as well: Abu Hammour et al. (2023) found that more Jordanian pharmacists were using ChatGPT to search for drug information and calculate drug dosages. Nevertheless, the uptake of these AI applications was far from being a standard practice and had some notable reluctance due to a perceived lack of accuracy, bias, and ethical considerations. On the whole, the existing body of research evidence on the education, training, and professional development of Jordanian pharmacists in the context of AI and digital technology points to a multi-faceted gap in education, policy, and ethical governance that would need to be addressed through curriculum reform, institutional investment, and professional development.

Jordan's AI and digital footprint is one of the smaller ones in comparison to surrounding countries. For example, Saudi Arabia's Vision 2030 plan has resulted in the development of the Seha Virtual Hospital, which is at the time of this essay writing the largest virtual hospital in the world, as well as the development of an AI chatbot "Dr. Hua" for automated diagnosis and treatment recommendations (Huda Ata, 2025; Ministry of Health, Saudi Arabia, 2025). Saudi Arabia has also developed a national AI infrastructure company called HUMAIN, which also displays a large amount of institutionalization of AI development in the country (HUMAIN, 2025). The UAE and Qatar have also incorporated AI and telehealth systems into their national healthcare initiatives, however, data about their impact is not readily available in the pharmacy practice literature (Obaid et al., 2022). In Jordan, initiatives have been more decentralized and with no unifying policies or large funding sources to bring them together.

2.6 Review of Empirical Studies and Identified Gaps

2.6.1 International Studies

In 2010, Loewen, Merrett, and De Lemos (2010) surveyed and interviewed hospital pharmacists in a Canadian sample, inquiring into the ways that pharmacists evaluated the impact of various activities they did on a day-to-day basis. The researchers found that pharmacists spent more time on activities they considered to have the most clinical impact (dispensing) while spending less time on tasks that, according to existing evidence, have a greater impact (taking medication histories and responding to drug information requests). They concluded that pharmacists should modify their daily practices to better align with evidence-based professional priorities (Loewen et al., 2010).

Ababneh et al. (2023) performed a systematic review of 55 studies from 26 countries on pharmacists' and public's attitudes toward extended community-pharmacy services. Pharmacists and the public had generally positive attitudes toward immunization, health promotion, and smoking cessation services; however, the services' implementation was limited by lack of time, workforce, and inter-professional collaboration. The authors highlighted that favorable attitude would not necessarily be converted to practice if there were not supportive policies and targeted training.

Beshir et al. (2022) examined 19 articles on the educational value of virtual patient simulations (VPS) in pharmacy education. Following PRISMA guidelines, the review offered strong evidence that VPS significantly outperformed traditional teaching methods in improving knowledge, clinical reasoning skills, and learner confidence. The authors recommended the integration of VPS in pharmacy curricula to strengthen experiential learning and address theory–practice gaps.

Zhou (2023) conducted an applied study of browser/server-based virtual-reality(VR) systems in China with the goal of pharmaceutical production and education. The author noted how the participants in the study, pharmacy students, were trained with the assistance of VR-based simulations, improving their hands-on competence and also lowering the accompanying cost and risk to safety. The author found that a VR system can be a scalable and effective method of improving professional training in the pharmaceutical sciences.

Raza et al. (2022) conducted a global review and summarized the major developments in the applications of artificial intelligence (AI) in pharmacy practice between 2015 and 2021. In the article, authors reported that applications of AI were reported in the fields of clinical decision support, prediction of drug interactions, monitoring adherence, and community-pharmacy management. The authors stressed the need for further researches to investigate ethical, regulatory, and governance aspects to ensure safe and effective implementation of AI in the healthcare system.

2.6.2 Middle Eastern Studies

Hasan et al. (2024) conducted a multinational cross-sectional study on "Knowledge, Attitude, and Practice among Pharmacy Students and Faculty Members towards Artificial Intelligence in Pharmacy Practice." This study had 1,700 participants from Jordan, Lebanon, Saudi Arabia, Egypt, Palestine, and Libya (n = 1,700). Despite 92.6% of the respondents reporting that they have heard of AI, only 39.5% of the respondents reported that their understanding level is good, and only 18.6% had received any formal training. The authors proposed the integration of AI into pharmacy curricula and an increase in training opportunities regionally.

Alkhudair et al. (2024) employed a quasi-experimental design to assess the use of VR in introductory pharmacy practice experiences (IPPE). 83 students from King Saud University participated in the study and were randomly assigned to a control (traditional) or experimental (VR) group. The VR group had significantly higher knowledge scores, confidence and satisfaction. The authors concluded that VR-based training should be scaled up to pharmacy schools to enhance experiential learning.

Bashir et al. (2020) conducted a cross-sectional study titled "Community Pharmacists' Perceptions, Awareness, and Practices regarding Counterfeit Medicines." In the research, the 229 participating pharmacists reported recognizing the counterfeit drug issue, but most did not possess adequate knowledge of law and detection practice. The study called for enhanced pharmacist education and strict legal policies regarding counterfeits.

Obaid et al. (2022) published a scoping review, "Pharmacy Practice and Clinical Pharmacy Research in the Middle East". The review, which analyzed 243 studies from 2009 to 2019, highlighted the rapid growth of clinical and pharmacy research in Saudi

Arabia and the UAE (with specific growth noted in the integration of artificial intelligence and the provision of clinical-pharmacy services), the much slower growth in Jordan and other bordering countries, and the need for regional investment in research capacity and digital-health implementation.

Saeed et al. (2024) aimed to examine pharmacy students' perception towards artificial intelligence (AI) in Sudan. This cross-sectional study included 412 pharmacy students who were asked to fill out an online questionnaire. The main findings of the study suggested that more than half of the respondents had no knowledge about AI in the field of pharmacy. Despite that, their overall attitude was positive, with around 70% agreeing with the use of AI in this area. The authors also underlined that there is still a difference between the knowledge and the attitude towards AI, and that the students' education must be adapted to further increase their digital and AI skills.

2.6.3 Jordanian Studies

Hasan et al. (2024) attempted to determine the perceptions of Jordanian pharmacists regarding artificial intelligence (AI) in a multinational cross-sectional study. They reported that the pharmacists had positive perceptions about the technology, excitement about AI adoption was growing, but there was a lack of actual implementation because of the unavailability of training and lack of strong institutional environment to support AI use. The authors suggested the need for formal education programs and improved organizational support for AI integration in pharmacy practice.

Abu Hammour et al. (2023), in their paper "ChatGPT in Pharmacy Practice: A Cross-sectional Exploration of Jordanian Pharmacists' Perception, Practice, and Concerns," described how Jordanian pharmacists used ChatGPT in their daily practice. Their survey of 412 participants has shown that pharmacists extensively use ChatGPT for drug information retrieval, but only 15–16% of pharmacists used ChatGPT for medication reconciliation or dosage calculations. The respondents have also expressed ethical and accuracy-related concerns, which have been pointed out as reasons to put in place regulatory oversight and training programs.

Odeh et al. (2021) evaluated the professional development experiences of pharmacists in Jordan. The study revealed that there was a very weak institutional policy towards the Continuing Professional Development (CPD) of pharmacists and an overreliance on informal learning approaches. The authors suggested that national policies and strategies for structured and planned CPD be developed, and should include digital health, leadership and AI-related competencies, to build capacity and strengthen the country's workforce.

A set of studies (Farha, 2017; Farha et al., 2018; Farha and Abu Farha, 2018, 2022) on the public's and pharmacists' perceptions toward some innovative pharmacy services including drive-thru pharmacy, breast cancer awareness, and smoking cessation counseling, which were conducted in Jordan using the cross-sectional study design, consistently reported positive perceptions among both pharmacists and public, but infrequent implementation of these services due to a lack of resources and institutional barriers. The studies consistently recommended investing in infrastructure, public engagement, and regulatory strengthening to improve and expand pharmacy services.

Adaileh and Alshawawreh (2021), in their analytical report “Measuring Digital Transformation Impact in Jordan”, suggested a way to assess digital transformation under the REACH2025 initiative of Jordan. They found that while healthcare and pharmacy were among the targeted industries, real-world adoption is limited and slow. The authors offered advice to have a unified national strategy to speed up digital transformation and help the pharmaceutical industry incorporate emerging technologies in a systematic and continuous way.

Taken together, the results from the Jordanian literature discussed above indicate that the use of digital technologies and tools in the Jordanian pharmacy sector is likely to progress in a way that is patchy, and not particularly coherent. In general, a generally high level of interest in and positive attitudes towards AI and digital technologies by Jordanian pharmacists is matched by a lack of national level preparedness and coordination, along with poorly-developed training capacity and a low level of institutional digital readiness. The development of national strategies for digital health, clear and coherent policy guidance for their use in the pharmacy sector, the reconfiguration of pharmacy education and curricula, and the investment in the capacity of educational and other institutions to teach and support digital technology and AI uptake will all be necessary in order for Jordan to make the transition to a system of technology-enabled and supported pharmaceutical care.

Table 2.1: Summary of empirical studies

Category	Author/Year	Title/Focus	Methodology	Key Findings
International Studies	Loewen et al. (2010)	Pharmacists' perceptions of the impact of care they provide	Mixed-methods (surveys + interviews)	Pharmacists overvalued dispensing, undervalued evidence-based tasks.
	Ababneh et al. (2023)	Attitudes, awareness, and perceptions of extended & drive-thru pharmacy	Systematic review (55 studies in 26 countries)	Positive attitudes, but limited implementation due to time and resource barriers.
	Beshir et al. (2022)	Virtual patient simulation in pharmacy education	Systematic review (19 studies, PRISMA)	VPS improved knowledge, decision-making, and self-confidence.
	Zhou (2023)	Application of VR systems in pharmaceutical production and education	Applied VR training study	VR reduced costs/risks and enhanced practical learning.
	Raza et al. (2022)	Artificial Intelligence in Pharmacy: Overview of innovations	Literature review (2015–2021 studies)	AI applied in decision support, adherence monitoring; need for governance.
Middle Eastern Studies	Hasan et al. (2024)	Knowledge, attitude, practice toward AI (students/faculty, 6 Arab countries)	Cross-sectional survey (n=1700)	High awareness, limited understanding and training.
	Alkhudair et al. (2024)	Integration of VR in Saudi pharmacy education (IPPE)	Quasi-experimental (Saudi students, n=83)	VR group scored higher, showed more confidence and satisfaction.
	Bashir et al. (2020)	Community pharmacists' perceptions of counterfeit	Cross-sectional survey (n=229)	Recognized risk but lacked legal knowledge and detection practices.

Category	Author/Year	Title/Focus	Methodology	Key Findings
		medicines (Egypt)		
	Obaid et al. (2022)	Pharmacy practice and research in the Middle East	Scoping review (243 studies, 2009–2019)	Strong growth in KSA/UAE; slower in Jordan and other countries.
	Saeed et al. (2024)	Pharmacy students' perceptions of AI (Sudan)	Cross-sectional survey (n=412)	Positive attitudes but weak knowledge; need curriculum integration.
Jordanian Studies	Hasan, Jarab & Salameh (2024)	Jordanian pharmacists' perceptions of AI (subset of regional study)	Cross-sectional (Jordanian sample)	Positive perceptions, limited adoption due to training/institutional gaps.
	Abu Hammour et al. (2023)	ChatGPT in pharmacy practice (Jordan)	Cross-sectional survey (n=412 pharmacists)	Used for drug info; low use for reconciliation/dosage; ethical concerns.
	Odeh et al. (2021)	Postgraduate pharmacist development in Jordan	Cross-sectional survey	Weak CPD policies, reliance on informal learning.
	Farha & Abu Farha (2017–2022)	Perceptions of innovative pharmacy services (Jordan)	Multiple cross-sectional surveys	Positive attitudes but limited implementation due to resource shortages.
	Adaileh & Alshawawreh (2021)	Digital transformation impact in Jordan (REACH2025)	Framework analysis	Healthcare/pharmacy prioritized, adoption slow; need unified strategy.

2.6.4 Research Gap and Rationale for the Study

The systematic review clearly indicates an international shift towards employing state-of-the-art digital resources for the purpose of education and practice in the pharmacy profession. In particular, AI, VR, AR, and MR have been cited in many articles outside of Canada for their potential in improving knowledge, clinical decision-making, and workflow (Beshir et al., 2022; Zhou, 2023; Raza et al., 2022). However, other systematic reviews in pharmacy practice have reported that pharmacists globally continue to experience challenges with time, education/training, and lack of support even though they see value in going digital (Ababneh et al., 2023; Loewen et al., 2010).

Regionally, Middle East-based studies also show positive awareness and attitude toward digital health but a slow pace of implementation in some countries. "For example, while nations like Saudi Arabia and the UAE have heavily invested in AI, VR-based training, and telepharmacy, the progress has been slower or limited to pilot studies in countries like Jordan and Egypt, with a regional gap between concept and implementation remaining." (Alkhudair et al., 2024; Obaid et al., 2022; Bashir et al., 2020).

The situation in Jordan is not dissimilar, as available research suggests an overall positive sentiment constrained by similar limitations at the level of infrastructure and policy. Jordanian pharmacists and pharmacy students have expressed interest and willingness in embracing AI and other similar technologies; however, their experiences in this regard have been at a surface level given the context of a fragmented system, lack of digital education, limited resources, and lack of a national plan in the direction of a technologically enabled healthcare system (Hasan et al., 2024; Abu Hammour et al., 2023; Odeh et al., 2021). Traditional didactic teaching methods are still prevalent in pharmacy education with limited focus on simulation and minimal evidence of AI-aided learning in the classroom (Alsharif & Nguyen, 2021). The result is a continued disconnect between technological awareness and application in both the classroom and practice.

The global and regional literature on the application of innovative technologies is gradually growing, however, the evidence on hospital pharmacists’ views and preparedness for their adoption in Jordan remains scant. The small number of studies that were conducted are either focused on the community pharmacists or students, or target public awareness, despite that hospital pharmacists are the key actors in the process of clinical decision-making and safety. The small body of studies on this topic represents a substantial and palpable gap in the national and regional digital transformation research.

Consequently, this study was undertaken with an aim of bridging this research and contextual void. Therefore, conducting the study with hospital pharmacists in Amman, Jordan, has been valuable as it allows in-depth investigation of their awareness, attitudes, and perceptions of adopting AI, VR, AR, and MR in pharmaceutical care; exploring the enabling and constraining factors of their adoption; and creating new evidence-based insights for guiding the national policy development, institutional decision-making, and curricular reformation. Bridging this identified research and contextual gap is crucial to ensure the Jordanian pharmacy practice is in congruence with the international digital health movement, enable the pharmacists to be ready for the AI-enabled healthcare environment, and ensure patient care is at its best level across Jordan.

Chapter Three

Methodology (Methods and Procedures)

3.1 Study Design

For the current study, a descriptive-analytical cross-sectional design was used to describe and measure hospital pharmacists' perceptions of the use of Artificial Intelligence (AI) applications in pharmacy practice in the city of Amman, Jordan. The current study focuses on assessing the current situation of awareness, views, and other aspects concerning AI applications without the need to control or manipulate variables, as in the case of experimentation. The data was collected using a validated, structured self-administered questionnaire. The data then be statistically analyzed.

3.2 Study Population and Sampling Techniques

3.2.1 Study Population

The study targeted all registered hospital pharmacists practicing in public or private hospitals within the city of Amman, Jordan.

3.2.2 Study Sample

The sample size was determined based on methodological considerations for descriptive analytical studies, feasibility, and accessibility to the target population rather than a formal statistical power calculation. Previous studies examining healthcare professionals' perceptions of artificial intelligence technologies have reported comparable sample sizes, indicating that a range of 60 to 100 participants is adequate for such research designs (Hasan et al., 2024; Jarab et al., 2023). Accordingly, a total of 84 pharmacists were recruited, which falls within the recommended range and was deemed sufficient to meet the objectives of the study and to allow for meaningful descriptive and multivariate statistical analyses. Participants were recruited using a purposive non-probability sampling approach, which is commonly used in descriptive analytical studies to target individuals with relevant characteristics and professional experience.

3.3 Study Tools

The major tool used for data collection is a structured, tone-reported survey designed from the literature review and modeled theories like the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT) (Davis, 1989; Venkatesh et al., 2003). The questionnaire will measure details such as pharmacists' mindfulness of diverse AI technologies, opinions about AI operation in drugstores, perceived benefits and limitations, and demographic data. Responses will be scored on a 5-point Likert scale ranging from" explosively Disagree" to" explosively Agree."

1. **Demographic and Professional Variables:** The pharmacists were asked to complete a sociodemographic data sheet containing:

- Age: (Less than 30 years, 30-39 years, 40 years and above)
- Gender (Male, Female)
- Years of Experience (Less than 5 years, 6 years and above)
- Educational Level (Bachelor's, Master's, and PharmD)
- Workplace type: (Public Hospital, Private Hospital)
- Job Role: (Clinical Pharmacist, Administrative Pharmacist, and Informatics Pharmacist)

2. AI and participation in digital health:

- Are you involved in decision-making processes at your workplace?
- Have you received any training in AI or digital health?

Hospital pharmacists' perceptions toward the application of modern technologies in pharmaceutical care services: This scale consisted eight sub-scales, including including awareness of AI and digital technologies, attitudes toward AI in pharmacy practice, confidence and readiness, perceived impact on the pharmacy profession, perceived benefits, perceived challenges, willingness to adopt and use, and institutional and environmental support, and each sub-scale consists of 5 items that are answered using a five-point Likert scale.

3.4 Validity and Reliability of the Study Tools

3.4.1 Content Validity

The validity of an instrument pertains to its ability to assess what it is intended to evaluate. Content validity can be evaluated by a panel of experts who determine if the measurement instrument satisfies the requirements (Kothari, 2004). The preliminary version of the questionnaire was reviewed by a panel of specialists from the Department of Pharmacy at Middle East University to obtain their insights regarding the suitability of the questionnaire items. The experts recommended varying or deleting some items, and after incorporating their suggestions, the questionnaire was found to be ready to roll out.

3.4.2 Reliability of the Study Tool

Internal consistency or reliability is “the extent to which any given measuring device yields identical results on repeated attempts” (Abbott & McKinney, 2012). The calculation of the coefficient of Cronbach's alpha is done through the use of the equation proposed by Cronbach (Cronbach, 1951) in assessing the internal consistency of the instruments used in the study. To ensure the questionnaire's high reliability, Cronbach's Alpha should always exceed 0.70 (Hinton, 2014). To assess the instrument’s reliability, the pilot sample (N = 20) is used before collecting data, with the results of the coefficient of Cronbach’s alpha presented in Table 3.1 in Appendix D.

As presented in Table 3.1, the overall reliability index of the scale, as indicated by Cronbach alpha, is 0.98. The Cronbach alpha values for the sub-scales that cover awareness of AI and digital technology, attitudes toward AI in pharmacy practice, confidence and readiness, perceived impact on pharmacy profession, perceived benefits, perceived challenges, willingness to adopt and use, and institutional and environmental support are respectively: awareness of AI and digital technology=0.92, attitudes toward AI in pharmacy practice=0.92, confidence and readiness=0.95, perceived impact on pharmacy profession=0.98, perceived benefits=0.90, perceived challenges=0.88, willingness to adopt and use=0.98, and institutional and environmental support=0.98.

3.5 Study Procedures

This study follows the following order:

1. A review of the literature and relevant studies conducted previously related to the research study being conducted was carried out to build the research instruments.
2. One of the techniques chosen is that of the questionnaire. This is because the questionnaire is developed to meet the objectives of the study. To enable the participants to complete the questionnaire effectively, an introduction that outlines the study and the way to complete the study is provided. Emphasis is placed on the fact that all the information collected will be treated with complete confidentiality and shall only be used for research. The first part of the questionnaire involves the demographics of those taking part in the study.
3. Before the data was gathered, this study was approved by the Institutional Review Board (IRB) at Middle East University.
4. A pilot study involving 20 pharmacists has been conducted to determine the reliability of the research instrument through the use of Cronbach's alpha. Additionally, the content validity of the research instrument has been confirmed through the presentation of the instrument to a panel of experts.
5. The researcher described the research methodology, data collection, instrument, and procedure, focusing on consent, confidentiality, and ethics. The voluntary nature of the research was ensured. The participants were made aware of their right not respond to any questions or withdraw from the study without any negative consequences.
6. The questionnaires collected were filtered to select the 84 questionnaires suitable for analysis, and the necessary statistical tests required to achieve the objectives of the study were carried out

3.6 Statistical Analysis

The raw data were coded and checked for missing data using Microsoft Excel 2016. Statistical Package of Social Science (SPSS) version 21 was used to analyze data, while the level of significance was set at < 0.05. The methods of statistical analysis are described as follows:

1. Reliability Test (Cronbach's Alpha Coefficient)

To verify the internal consistency of the study tool, Cronbach's alpha coefficient is calculated in SPSS version 21 using the equation proposed by Cronbach (1951).

2. Descriptive Statistics

Descriptive statistics, such as the arithmetic mean, the standard deviation, the frequencies, and the percentages, were used to describe and summarize data. The socio-demographics and characteristics of the sample are described using frequency and percentage estimates. The sub-variables of the instrument were described using the arithmetic mean and standard deviation.

3. Pearson Correlation

This test measured the correlations among study variables, including awareness of AI and digital technologies, attitudes toward AI in pharmacy practice, confidence and readiness, perceived impact on the pharmacy profession, perceived benefits, perceived challenges, willingness to adopt and use, and institutional and environmental support.

4. Linear Regression

This test was employed to measure the impact each of participate in decision-making processes in your workplace and receive training in artificial intelligence or digital health on dependent variables, including awareness of AI and digital technologies, attitudes toward AI in pharmacy practice, confidence and readiness, perceived impact on the pharmacy profession, perceived benefits, perceived challenges, willingness to adopt and use, and institutional and environmental support.

5. Multivariate Analysis of Variance (MANOVA)

This test was applied to measure the differences in awareness of AI and digital technologies, attitudes toward AI in pharmacy practice, confidence and readiness, perceived impact on the pharmacy profession, perceived benefits, perceived challenges, willingness to adopt and use, and institutional and environmental support attributed to gender, age, experience years, and work type.

3.7 Ethical Considerations

Before the start of data gathering, approval for conducting the research was sought from the Institutional Review Board (IRB)- (2025723) of the Middle East University (see Appendix E). The written consent from the participants was the pharmacist's consent form after the researcher had thoroughly discussed the nature of the research study. The researcher told the participants that their selection to join the study is voluntary, that all the collected data on them shall remain confidential by the principal researcher using a password-protected personal computer, and that they are free to withdraw from the study whenever they want without repercussions.

Chapter Four

Results of the Study

4.1 Descriptive Statistics of Study Sample

A total of 84 respondents participated in the study, including 79.8% females and 20.2% males. Table 4.1 shows the sociodemographic characteristics of the study participants.

Table (4.1): Descriptive statistics of the demographic, professional, and AI-related variables within the study sample

Nature of the study variables	Variable	Categories of Variable	N (%)
Demographic and Professional Variables	**Gender**	Male	17 (20.2%)
		Female	67 (79.8%)
	Years of Experience	Less than 5 years	37 (44%)
		6 years and above	47 (56%)
	Educational level	Bachelor's	67 (79.8%)
		Master's	14 (16.7%)
		PharmD	3 (3.6%)
	Age	Under 30 Years	46 (54.8%)
		30-39 Years	31 (36.9%)
		40 years and above	7 (8.3%)
	Workplace type	Public Hospital	32 (38.1%)
		Private Hospital	52 (61.9%)
	Job Role	Clinical Pharmacist	76 (90.5%)
		Administrative Pharmacist	6 (7.1%)
		Informatics Pharmacist	2 (2.4%)
AI and participation in digital health	**Are you involved in decision-making processes at your workplace?**	No	7 (8.3%)
		Yes	77 (91.7%)
	Have you received any training in AI or digital health?	No	10 (11.9%)
		Yes	74 (88.1%)

***All the variables in the Table are categorical, in which categorical variables were described using frequencies and percentages N (%).**

As shown in Table 4.1, the majority of pharmacists (37.1%) have 6-10 years of experience or more, with 56% falling into this category. Conversely, a minority have less than 5 years of experience in their field. Additionally, 79.8% reported that their highest level of education is a bachelor's degree. The findings also indicate that most respondents are under 30 years old (54.8%), while a smaller percentage are aged 40 years or older. In terms of job roles, the majority of respondents (90.5%) have been working for 6 years or more, while only a minority serve as administrative pharmacists (7.1%) or informatics pharmacists (2.4%). Regarding AI and participation in digital health, 91.7% of pharmacists involved in decision-making processes at your workplace, and 88.1% received training in AI or digital health.

4.2 Hospital Pharmacists' Perceptions Toward the Application of Modern Technologies in Pharmaceutical Care Services

The following Table (4.2) illustrates pharmacists' perceptions toward the Application of modern technologies in pharmaceutical care services after calculating means and standard deviations.

Table (4.2): Descriptive statistics of the Hospital Pharmacists' Perceptions Toward the Application of Modern Technologies in Pharmaceutical Care Services

Variable	Min-Max	Mean	SD
Awareness of AI and Digital Technologies	1.40 - 5	3.96	0.66
Attitudes Toward AI in Pharmacy Practice	1.60 - 5	4.03	0.65
Confidence and Readiness	2 – 5	4.07	0.63
Perceived Impact on the Pharmacy Profession	1.40 - 5	4.11	0.66
Perceived Benefits	1 – 5	4.14	0.71
Perceived Challenges	2 – 5	4.15	0.60
Willingness to Adopt and Use	2 – 5	4.20	0.60
Institutional and Environmental Support	1.80 - 5	4.14	0.73

The results presented in Table 4.2 indicate that "Willingness to Adopt and Use" achieved the highest mean score of 4.20 (±0.60), ranking first. This was followed closely by "Perceived Challenges," which ranked second with a score of 4.15 (±0.60). "Institutional and Environmental Support" came in third with a mean score of 4.14 (±0.71), tying with another "Perceived Challenges" entry, which also scored 4.14 (±0.71) but ranked fourth. "Perceived Impact on the Pharmacy Profession" was fifth, with a mean of 4.11 (±0.66), while "Confidence and Readiness" ranked sixth with a score of 4.07 (±0.63). "Attitudes Toward AI in Pharmacy Practice" followed in seventh place with a mean score of 4.03 (±0.65). Finally, "Awareness of AI and Digital Technologies" had the lowest ranking, with a score of 3.96 (±0.66). All mean scores were above the midpoint of 3 on the Likert scale, indicating a generally high level of agreement across all scales. Detailed descriptive statistics for each scale's items are provided below.

4.2.1 Measuring the Levels of Awareness and Attitudes of AI and Digital Technologies among Hospital Pharmacists' Perceptions

For the items on the AI and digital Technologies awareness and attitudes scales, positive/high frequency indicates the percentage of agreement (total of strongly agree and agree), and negative/low frequency indicates the percentage of disagreement (total of strongly disagree and disagree). The mean and standard deviation were calculated to assess the levels of awareness of AI and digital technologies among hospital pharmacists. The results were presented in detail as follows.

4.2.2 Levels of Awareness of AI and Digital Technologies among Hospital Pharmacists.'

The following Table (4.3) illustrates pharmacists' awareness levels of artificial intelligence and digital technologies after calculating frequencies, percentages, means, and standard deviations.

Table (4.3): Descriptive statistics of the level of awareness of artificial intelligence and digital technologies from the perspective of pharmacists

No.	Item	Positive/ high frequency N (%)	Neutral N (%)	Negative/ low frequency N (%)	M±SD
1	I am aware of various modern technologies (MTs) used in healthcare and pharmacy.	68 (81%)	12 (14.3%)	4 (4.7%)	**3.82±0.76**
2	I have encountered modern technologies (MTs) in my professional practice.	73 (87%)	7 (8.3%)	4 (4.7%)	**4.04±0.70**
3	I can differentiate between Artificial Intelligence (AI), Virtual Reality (VR),	68 (81%)	11 (13%)	5 (6%)	**3.93±0.83**

No.	Item	Positive/ high frequency N (%)	Neutral N (%)	Negative/ low frequency N (%)	M±SD
	and Augmented Reality (AR).				
4	I understand how MTs function in prescription validation and drug interaction detection.	72 (85.7%)	5 (6%)	7 (8.3%)	**3.96±0.90**
5	I am familiar with pharmacy information systems and how they integrate with MTs.	75 (89.3%)	5 (6%)	4 (4.7%)	**4.05±0.73**

Hospital pharmacists generally showed a positive awareness towards artificial intelligence and digital technologies, as indicated in the Table. The mean scores for all items exceeded the midpoint of 3.0. Most participants reported familiarity with pharmacy information systems and their integration with modern technologies (MTs), scoring a mean of 4.05 ± 0.73 (89.3% agreed versus 5% not-agreed), and have encountered modern technologies (MTs) in their professional practice, with a mean score of 4.04 ± 0.70 (87% agreed versus 5% not-agreed). In comparison, awareness of various modern technologies used in healthcare and pharmacy received a slightly lower mean score of 3.82 ± 0.76 (81% agreed versus 5% not-agreed).

4.2.3 Levels of Attitudes Toward AI and Digital Technologies among Hospital Pharmacists' Perceptions

The following Table (4.4) shows pharmacists' attitudes towards artificial intelligence and digital technologies after calculating frequencies, percentages, means, and standard deviations.

Table (4.4): Descriptive statistics of the level of attitudes toward AI in pharmacy practice from the perspective of pharmacists in public and private hospitals

No.	Item	Positive/high frequency (%)	Neutral	Negative/low frequency (%)	M±SD
1	Artificial Intelligence (AI) is essential for improving pharmaceutical care.	73 (87%)	7 (8.3%)	4 (4.7%)	3.99±0.77
2	I believe AI can help pharmacists make better clinical decisions.	72 (85.7%)	7 (8.3%)	5 (6%)	3.96±0.75

No.	Item	Positive/high frequency (%)	Neutral	Negative/low frequency (%)	M±SD
3	I am enthusiastic about the use of AI in pharmacy practice.	71 (84.5%)	8 (9.5%)	5 (6%)	4.01±0.74
4	I support the integration of AI in pharmacy training and education.	75 (89.3%)	6 (7.1%)	3 (3.6%)	4.07±0.65
5	I believe that using AI improves the efficiency and accuracy of pharmacy services.	77 (91.6%)	3 (3.6%)	4 (4.7%)	4.12±0.68

Hospital pharmacists typically exhibited positive attitudes towards artificial intelligence (AI) and digital technologies. This is reflected in the data, where the mean scores for all items exceeded the midpoint of 3.0. Most participants believe that using AI improves the efficiency and accuracy of pharmacy services, with a mean score of 4.12±0.68; 91.7% agreed, and only 4.7% disagreed. Additionally, they demonstrated support for integrating AI into pharmacy training and education, with a mean score of 4.07±0.65; 89.3% agreed, while 3.6% disagreed. In contrast, the statement regarding the belief that AI can help pharmacists make better clinical decisions received a slightly lower mean score of 3.96±0.75, with 85.7% agreeing and 6% disagreeing.

4.3 Measuring the Levels of Perceived Benefits and Challenges of AI Technologies in Pharmaceutical Practice

The perceived benefits and challenges of AI technologies in pharmaceutical practice measures show positive/high frequency for items that strongly agree and agree, and negative/low frequency for items that strongly disagree and disagree. The mean and standard deviation measured hospital pharmacists' AI and digital technology awareness. The findings are detailed below.

4.3.1 Perceived Benefits of AI Technologies in Pharmaceutical Practice

The frequencies, percentages, means, and standard deviations were calculated to measure the levels of perceived benefits towards AI from the perspective of pharmacists. The results are shown in Table 4.5.

Table (4.5): Descriptive statistics of the level of perceived benefits towards AI from the perspective of pharmacists in public and private hospitals

No.	Item	Positive/high frequency (%)	Neutral	Negative/low frequency (%)	M±SD
1	AI technologies increase efficiency and reduce workload.	78 (92.9%)	2 (2.4%)	4 (4.7%)	4.14±0.78
2	AI improves decision-making accuracy in pharmacy services.	74 (88.1%)	6 (7.1%)	4 (4.7%)	4.08±0.76
3	AI helps in detecting harmful drug interactions and contraindications.	76 (90.5%)	3 (3.6%)	5 (5.9%)	4.11±0.82
4	Modern technologies help provide better patient-centered care.	77 (91.7%)	3 (3.6%)	4 (4.7%)	4.15±0.75
5	AI systems provide data-driven insights for pharmaceutical interventions.	79 (94%)	2 (2.4%)	3 (3.6%)	4.21±0.71

From the Table, there is a high positive view among pharmacists regarding the advantages of artificial intelligence (AI) technology in pharmacy practice, since positive ratings are over 88% for all items. The item with the highest mean rating (4.21±0.71) is concerned with the provision of intelligent systems for generating insights based on data for pharmaceutical intervention. This had the highest mean rating with 94% agreeing, but only 3.6% disagreed to provide a clear indication of appreciation of AI's contribution to pharmaceutical decision-making and intervention. Further, they showed Modern technologies aid or assist in providing better patient-centered care with a mean of 4.15±0.75. In this case, 91.7% agreed, but 4.7% of pharmacists disagreed. The lowest mean rating of 4.08±0.76 was, however, recorded under AI technology that improves the accuracy of decision-making regarding pharmacy services. In this case, 88.1% agreed, with only 4.7% disagreeing. Negative or low percentages were minimal, and the relatively low standard deviations suggest a uniform opinion among the participants in the sample.

4.3.2 Perceived Challenges of AI Technologies in Pharmaceutical Practice

The frequencies, percentages, means, and standard deviations were calculated to assess levels of perceived AI-related challenges from the perspective of pharmacists. The following Table (4.6) shows the results.

Table (4.6): Descriptive statistics of the level of perceived challenges towards AI from the perspective of pharmacists in public and private hospitals

No.	Item	Positive/high frequency (%)	Neutral	Negative/low frequency (%)	M±SD
1	I lack sufficient training in using AI tools in pharmacy.	77 (91.7%)	5 (6%)	2 (2.3%)	4.15±0.63
2	Our hospital lacks the infrastructure to support AI implementation.	78 (92.8%)	3 (3.6%)	3 (3.6%)	4.17±0.66
3	There is resistance from senior staff regarding the use of AI.	77 (91.7%)	4 (4.8%)	3 (3.6%)	4.19±0.68
4	I fear patient data privacy breaches when using AI systems.	72 (85.7%)	9 (10.7%)	3 (3.6%)	4.08±0.76
5	Policies and regulations around AI use in pharmacy are unclear.	75 (89.3%)	7 (8.3%)	2 (2.3%)	4.14±0.66

This Table shows that pharmacists rate the challenges associated with implementing artificial intelligence (AI) technologies in pharmacy practice as relatively high. The challenge of senior staff resistance to AI use scored the highest mean, with a mean score of 4.19±0.68; 91.7% agreed, while 3.6% disagreed, reflecting a clear awareness of the human obstacles to adopting these technologies. Conversely, concerns about patient data privacy had the lowest mean score, 4.08±0.76; 85.7% agreed, while 3.6% disagreed, indicating that this challenge is perceived as less severe than the others.

4.4 The Degree of Adsorption on the AI Technologies in Pharmacy from the Perspective of Pharmacists

Positive/high frequency indicates agreement (strongly agree and agree) on confidence and readiness toward AI and on the willingness to adopt and use AI, whereas negative/low frequency suggests disagreement. Details of the findings follow.

4.4.1 Levels of Confidence and Readiness toward AI from the Perspective of Pharmacists

The frequencies, percentages, means, and standard deviations were calculated to measure pharmacists' perceptions of AI-related confidence and readiness. Table 4.7 illustrates the results.

Table (4.7): Descriptive statistics of the level of confidence and readiness toward AI in pharmacy practice from the perspective of pharmacists in public and private hospitals

No.	Item	Positive/high frequency (%)	Neutral	Negative/low frequency (%)	M±SD
1	I feel confident in using Artificial Intelligence (AI) in pharmacy services.	73 (87%)	7 (8.3%)	4 (4.8%)	4.02±0.79
2	I am ready to use AI tools if proper training is provided.	71 (84.5%)	11 (13.1%)	2 (2.4%)	4.05±0.73
3	I believe I can quickly learn how to operate AI-based pharmacy systems.	73 (86.9%)	9 (10.7%)	2 (2.4%)	4.08±0.66
4	I am open to adapting my workflow to include AI applications.	76 (90.5%)	6 (7.1%)	2 (2.4%)	4.12±0.63
5	I feel supported in my workplace to experiment with new AI tools.	72 (85.7%)	11(13.1%)	1 (1.2%)	4.09±0.65

This Table shows that the level of trust and readiness to use artificial intelligence (AI) technologies among pharmacists was generally high. The statement "I am open to adapting my workflow to include AI applications" had the highest mean score, with a mean score of 4.12±0.63; 90.5% agreed, while 2.4% disagreed, indicating a positive level of professional readiness to adopt these technologies. Conversely, the statement "feeling confident in using AI in pharmacy services "I feel confident in using Artificial Intelligence (AI) in pharmacy services", with a mean score of 4.02±0.79; 87% agreed, while 4.8% disagreed, scored relatively low, though still within the high range, indicating a need further to strengthen practical trust through training and institutional support.

4.4.2 Levels of Willingness to Adopt and Use AI from the Perspective of Pharmacists

The pharmacists' perceptions regarding their willingness to adopt and use AI were evaluated using frequencies, percentages, means, and standard deviations.

Table 4.8 illustrates the results.

Table (4.8): Descriptive statistics of the level of willingness to adopt and use AI from the perspective of pharmacists in public and private hospitals

No.	Item	Positive/high frequency (%)	Neutral	Negative/low frequency (%)	M±SD
1	I am willing to integrate AI tools into my daily pharmacy work.	76 (90.5%)	6 (7.1%)	2 (2.4%)	4.15±0.65
2	I would recommend AI tools to colleagues in similar roles.	78 (92.9%)	3 (3.6%)	3 (3.6%)	4.18±0.66
3	I will participate in AI-related training if offered by the hospital.	78 (92.9%)	4 (4.8%)	2 (2.4%)	4.20±0.64
4	I am likely to support future investment in AI systems in my department.	78 (92.9%)	5 (6%)	1 (1.2%)	4.21±0.60
5	I believe AI should be included in pharmacy education and training programs.	79 (94%)	3 (3.6%)	2 (2.4%)	4.24±0.69

Hospital pharmacists generally showed a positive willingness to adopt and use towards AI, as indicated in the Table. The mean scores for all items exceeded the midpoint of 4. Most participants reported believe AI should be included in pharmacy education and training programs, scoring a mean of 4.24±0.69 (94% agreed versus 2.4% not-agreed), and likely to support future investment in AI systems in department, with a mean score of 4.21±0.60 (92.9% agreed versus 1.2% not-agreed). In comparison, willing to integrate AI tools into daily pharmacy work received a slightly lower mean score of 4.15±0.65 (90.5% agreed versus 2.4% not-agreed).

4.5 The Degree of Adsorption on the AI Technologies in Pharmacy from the Perspective of Pharmacists

On the institutional and environmental support towards AI and perceived impact of AI scales, positive/high frequency indicates agreement (total of strongly agree and agree) and negative/low frequency shows disagreement. AI and digital technology awareness among hospital chemists was measured by mean and standard deviation. Detailed results follow.

4.5.1 Levels of Institutional and Environmental Support towards AI from the Perspective of Pharmacists

Pharmacists' perceptions of institutional and environmental support for AI were calculated using frequencies, percentages, means, and standard deviations. Table 4.9 illustrates the results.

Table (4.9): Descriptive statistics of the level of institutional and environmental support towards AI from the perspective of pharmacists in public and private hospitals

No.	Item	Positive/high frequency (%)	Neutral	Negative/low frequency (%)	M±SD
1	My hospital encourages the use of digital health technologies.	75 (89.3%)	5 (5.9%)	4 (4.8%)	4.15±0.74
2	There is a strategic plan for AI adoption in our pharmacy department.	74 (88.1%)	5 (5.9%)	5 (5.9%)	4.09±0.80
3	My hospital provides regular training and workshops on emerging technologies.	77 (91.7%)	2 (2.4%)	5 (5.9%)	4.13±0.82
4	Leadership is supportive of innovation in pharmaceutical care.	77 (91.7%)	5 (5.9%)	2 (2.4%)	4.21±0.66
5	There are funds available for digital health transformation projects.	75 (89.3%)	6 (7.1%)	5 (5.9%)	4.11±0.82

Hospital pharmacists generally demonstrated a positive attitude toward institutional and environmental support, as shown in the data. The average scores for all items exceeded the midpoint of 4. Most participants indicated that leadership supports innovation in pharmaceutical care, with a mean score of 4.21±0.66 (91.7% agreed, while only 2.4% disagreed). Additionally, participants noted that the hospital encourages the use of digital health technologies, reporting a mean score of 4.15±0.74 (89.3% agreed, compared to 4.8% who disagreed). In comparison, the statement regarding a strategic plan for AI adoption in the pharmacy department received a slightly lower mean score of 4.09±0.80 (88.1% agreed versus 5.9% disagreed).

4.5.2 Levels of Perceived Impact of AI on the Pharmacy Profession from the Perspective of Pharmacists

Frequencies, percentages, means, and standard deviations were used to measure the levels of perceived impact of AI on the pharmacy profession from chemists' perspectives. The results are shown in Table 4.10.

Table (4.10): Descriptive statistics of the level of perceived impact on the pharmacy profession from the perspective of pharmacists in public and private hospitals

No.	Item	Positive/high frequency (%)	Neutral	Negative/low frequency (%)	M±SD
1	AI will enhance pharmacists' clinical roles rather than replace them.	75(89.3%)	6 (7.1%)	3 (3.6%)	4.12±0.73
2	AI can reduce human errors in medication dispensing.	75 (89.3%)	4 (4.8%)	5 (6%)	4.06±0.81
3	The use of AI will allow pharmacists to focus more on patient care.	78 (92.8%)	3 (3.6%)	3 (3.6%)	4.14±0.75
4	AI might lead to fewer job opportunities for pharmacists in the future.	77 (91.7%)	2 (2.4%)	5 (6%)	4.09±0.70
5	The role of pharmacists will evolve through the continuous adoption of AI.	78 (92.8%)	7 (8.3%)	2 (2.4%)	4.13±0.65

Hospital pharmacists generally perceive a positive impact of artificial intelligence (AI) on the pharmacy profession, as shown in the Table. The mean scores for all items exceeded the midpoint score of 4. Most participants reported that the use of AI would allow pharmacists to focus more on patient care, with a mean score of 4.14±0.75, 92.8%

in agreement, and only 3.6% disagreeing. Additionally, they noted that the role of pharmacists will evolve with the continuous adoption of AI, which received a mean score of 4.13±0.65, with 92.8% agreeing and 2.4% disagreeing. In comparison, the statement regarding the reduction of human errors in medication dispensing received a slightly lower mean score of 4.06±0.81, with 89.3% in agreement and 6% disagreeing.

4.6 Association between Study Variables

A Pearson product-moment correlation was conducted to measure the correlation between study variables, including awareness of AI and digital technologies, attitudes toward AI in pharmacy practice, confidence and readiness, perceived impact on the pharmacy profession, perceived benefits, perceived challenges, willingness to adopt and use, and institutional and environmental support. The correlation matrix between the variables in the study is presented in Table 4.11.

Table (4.11): The correlation analysis between study variables (n=84)

		1	2	3	4	5	6	7
1	Awareness of AI and Digital Technologies	-						
2	Attitudes Toward AI in Pharmacy Practice	0.758**						
3	Confidence and Readiness	0.631**	0.827**					
4	Perceived Impact on the Pharmacy Profession	0.727**	0.836**	0.863**				
5	Perceived Benefits	0.661**	0.637**	0.763**	0.802**			
6	Perceived Challenges	0.584**	0.582**	0.651**	0.707**	0.625**		
7	Willingness to Adopt and Use	0.657**	0.737**	0.721**	0.773**	0.716**	0.803**	
8	Institutional and Environmental Support	0.677**	0.602**	0.632**	0.667**	0.763**	0.678**	0.780**

**** p-value is less than 0.01 and *p-value is less than 0.05**

The correlation matrix indicates the existence of positive correlations between all the studied variables ($p < 0.01$), with values ranging from 0.58 to 0.86. There existed a strong positive relationship between the perceived impact of AI and the confidence and readiness (r=0.86; Strong relationship; n=84; P-value < 0.001), indicating that increased levels of trust and preparation among pharmacists are associated with greater levels of awareness about the impact of AI on the pharmacy profession. The results revealed that a strong association existed between the groups' attitudes towards the adoption of AI and the perceived (r=0.84, Strong relationship, n=84, P-value < 0.001) and the confidence and readiness (r=0.83, Strong relationship, n=84, P-value < 0.001), which confirm the essential role of attitudes as an influential factor for the adoption of novel technologies.

The association coefficients associated of awareness of AI and digital technologies (r=0.58, moderate correlation, n=84, P-value<0.001), attitudes toward AI in pharmacy practice (r=0.58, moderate correlation, n=84, P-value<0.001), confidence and readiness (r=0.65, moderate correlation, n=84, P-value<0.001), perceived impact on the pharmacy profession (r=0.71, moderate correlation, n=84, P-value<0.001), perceived benefits (r=0.62, moderate correlation, n=84, P-value<0.001), and institutional and environmental support (r=0.68, moderate correlation, n=84, P-value<0.001) with perceived challenges were somewhat lower than those of other variables, although they remained statistically significant.

4.7 Predict the levels of application of modern technologies in pharmaceutical care service by participating in decision-making processes

Linear regression was employed using SPSS Version 28 to measure the impact of participating in decision-making processes on the level of application of modern technologies in pharmaceutical care services. The results are shown in the following Table.

Table (4.12) Regression coefficients to predict how participating in decision-making processes predicts levels of application of modern technologies in pharmaceutical care service

Outcome/predictors	Unstandardized Coefficients	Standardized Coefficients - Beta	t. test	P -value	R^2	Adj R^2	F-Value
	B	β					
Awareness of AI and Digital Technologies					0.11	0.10	10.46
Constant	3.229		13.68	0.001			
Participating in decision-making processes.	0.797	0.336	3.23	**0.002***			
Attitudes Toward AI in Pharmacy Practice					**0.05**	**0.04**	**4.48**

Outcome/predictors	Unstandardized Coefficients	Standardized Coefficients - Beta	t. test	P -value	R^2	Adj R^2	F-Value
	B	β					
Constant	3.543		14.77	0.001			
Participating in decision-making processes.	0.530	0.227	2.115	**0.037***			
Confidence and Readiness					**0.001**	**-0.011**	**0.10**
Constant	4.000		16.60	0.001			
Participating in decision-making processes.	0.081	0.035	0.320	0.750			
Perceived Impact on the Pharmacy Profession					**0.013**	**0.01**	**1.10**
Constant	3.857		15.36	0.001			
Participating in decision-making processes.	0.275	0.115	1.050	0.30			
Perceived Benefits					**0.04**	**0.03**	**3.68**
Constant	3.657		13.90	0.001			
Participating in decision-making processes.	0.527	0.207	1.919	0.058			
Perceived Challenges					**0.001**	**-0.011**	**0.08**
Constant	4.086		17.95	0.001			
Participating in decision-making processes.	0.068	0.031	0.28	0.78			
Willingness to Adopt and Use					**0.04**	**0.02**	**3.01**
Constant	3.83		17.20	0.000			
Participating in decision-making processes.	0.403	0.188	1.73	0.087			
Institutional and Environmental Support					**0.10**	**0.08**	**8.59**
Constant	3.400		12.84	0.000			

Outcome/predictors	Unstandardized Coefficients	Standardized Coefficients - Beta	t. test	P -value	R^2	Adj R^2	F-Value
	B	β					
Participating in decision-making processes.	0.810	0.308	2.93	**0.004***			
Application of Modern Technologies					**0.05**	**0.03**	**3.95**
Constant	3.70		17.61	**0.001**			
Participating in decision-making processes.	0.44	0.21	1.99	**0.04***			

***If the p-value is less than 0.05, the result is considered statistically significant.**

The results revealed that participation in decision-making processes explains 3% of the variance in hospital pharmacists' perceptions of the application of modern technologies in pharmaceutical care services ($F (1, 82) = 3.95$, $p < 0.05$), with a standardized beta of 0.21. This indicates that individuals who participate in decision-making activities have more favorable perceptions of the application of modern technologies compared to those who do not.

The findings revealed that involvement in decision-making processes accounts for 10% of the variance in awareness of AI and digital technologies ($F (1, 82) = 10.46$, $p < 0.05$), with a standardized beta coefficient of 0.34. This means that people who take part in decision-making activities show greater awareness of AI and digital technologies than people who do not. Results showed that involvement in decision-making activities was a strong predictor of attitudes towards AI in pharmacy practice, explaining 4% of the variance ($F (1,82) = 4.48$, $p <0.05$), with a standardized beta coefficient of 0.23. This indicates that people who take part in decision-making activities show more positive attitudes towards AI use in pharmacy practice than people who do not. Results showed that involvement in decision-making activities was a strong predictor of institutional and environmental support, explaining 8% of the variance ($F (1,82) = 8.59$, $p <0.05$), with a standardized beta coefficient of 0.31. This indicates that people who take part in decision-making activities show greater awareness of institutional and environmental support than people who do not.

4.8 Predict the levels of application of modern technologies in pharmaceutical care service by receiving training in AI or digital health

Linear regression was employed in SPSS Version 28 to assess the impact of training in AI or digital health on the level of application of modern technologies in pharmaceutical care services. The results are shown in the following Table.

Table (4.13) Regression coefficients to predict how receiving training in AI or digital health predicts levels of application of modern technologies in pharmaceutical care service

Outcome/predictors	Unstandardized Coefficients	Standardized Coefficients-Beta	t. test	P -value	R^2	Adj R^2	F-Value
	B	β					
Awareness of AI and Digital Technologies					0.15	0.14	14.93
Constant	3.260		16.90	0.001			
Receiving training in AI or digital health.	0.794	0.392	3.86	0.001			
Attitudes Toward AI in Pharmacy Practice					**0.12**	**0.11**	**11.26**
Constant	3.420		17.70	0.001			
Receiving training in AI or digital health.	0.691	0.348	3.36	0.001			
Confidence and Readiness					**0.13**	**0.12**	**12.07**
Constant	3.460		18.38	0.001			
Receiving training in AI or digital health.	0.697	0.358	3.47	0.001			
Perceived Impact on the Pharmacy Profession					**0.12**	**0.11**	**11.47**
Constant	3.480		17.57	0.001			
Receiving training in AI or digital health.	0.715	0.350	3.39	0.001			
Perceived Benefits					**0.20**	**0.19**	**20.82**
Constant	3.280		16.33	0.001			
Receiving training in AI or digital health.	0.977	0.450	4.56	0.001			
Perceived Challenges					**0.06**	**0.05**	**5.55**
Constant	3.740		20.28	0.001			
Receiving training in AI or digital health.	0.463	0.252	2.36	0.021			

Outcome/predictors	Unstandardized Coefficients	Standardized Coefficients-Beta	t. test	P -value	R^2	Adj R^2	F-Value
	B	β					
Willingness to Adopt and Use					**0.17**	**0.16**	**16.38**
Constant	3.540		20.45	0.001			
Receiving training in AI or digital health.	0.746	0.408	4.05	0.001			
Institutional and Environmental Support					**0.32**	**0.31**	**38.95**
Constant	3.020		15.75	0.001			
Receiving training in AI or digital health.	1.275	0.567	6.241	0.001			
Application of Modern Technologies					**0.21**	**0.20**	**21.71**
Constant	3.40		21.25	**0.001**			
Receiving training in AI or digital health.	0.79	0.46	4.66	**0.001**			

***If the p-value is less than 0.05, the result is considered statistically significant.**

The results showed that receiving training in AI or digital health accounts for 20% of the differences in hospital pharmacists' views on the use of modern technologies in pharmaceutical care services, which is supported by a significant statistical result (F(1, 82) = 21.71, p < 0.05). This indicates that pharmacists with training in AI, or digital health, have a more favorable perception of the application of modern technologies than those who do not.

The findings indicated that receiving training in AI or digital health accounted for the following percentages of variance in various areas: 14%, 11%, 12%, 11%, 19%, 5%, 16%, and 31% in awareness of AI and digital technologies (F(1, 82) = 14.9, p < 0.05); attitudes toward AI in pharmacy practice (F(1, 82) = 11.26, p <0.05); confidence and readiness (F(11, 332) = 12.07, p <0.05); perceived impact on the pharmacy profession (F(1, 82) = 11.47, p <0.05); perceived benefits (F(1, 82) = 20.82, p < 0.05); perceived challenges (F(1, 82) = 5.55, p << 0.05); willingness to adopt and use (F(1, 82) = 16.38, p < 0.05); and institutional and environmental support (F(1, 82) = 38.95, p < 0.05), respectively.

The standardized beta coefficients for various factors related to the awareness of AI and digital technologies are as follows: 0.39 for awareness of AI and digital technologies, 0.35 for attitudes toward AI in pharmacy practice, 0.36 for confidence and readiness, 0.35

for perceived impact on the pharmacy profession, 0.45 for perceived benefits, 0.25 for perceived challenges, 0.41 for willingness to adopt and use, and 0.57 for institutional and environmental support. These findings show that pharmacists with training in AI or digital health show higher awareness, more favorable attitudes towards AI use in pharmacy, increased levels of confidence and readiness, a greater perceived impact of AI on the pharmacy profession, greater perceived benefits, greater perceived challenges, greater willingness to adopt and utilize this technology, and greater organizational and environmental support relative to those without this type of training.

4.9 Differences in Pharmacists' Attitudes by Demographic Characteristics

A multivariate analysis of variance (MANOVA) was employed to assess the effect of demographic variables on the combined dependent variables. The multivariate test statistics, including Pillai’s Trace, Wilks’ Lambda, Hotelling’s Trace, and Roy’s Largest Root, are summarized in Table 4.14.

Table (4.14): Results of Multivariate Analysis (MANOVA) for demographic variables

Effect		Statistic Value	p-value
Gender	Pillai's Trace	0.129	0.382
	Wilks' Lambda	0.871	0.382
	Hotelling's Trace	0.148	0.382
	Roy's Largest Root	0.148	0.382
Age	Pillai's Trace	0.509	0.002
	Wilks' Lambda	0.512	0.001
	Hotelling's Trace	0.911	0.001
	Roy's Largest Root	0.864	0.001
Experience	Pillai's Trace	0.400	0.001
	Wilks' Lambda	0.600	0.001
	Hotelling's Trace	0.666	0.001
	Roy's Largest Root	0.666	0.001
Workplace	Pillai's Trace	0.158	0.223
	Wilks' Lambda	0.842	0.223
	Hotelling's Trace	0.188	0.223
	Roy's Largest Root	0.188	0.223

Using Wilks' Lambda as the leading indicator in a multivariate analysis of variance (MANOVA), the results showed no statistically significant differences in pharmacists' attitudes attributed to gender (Wilks' Lambda = 0.871, $p = 0.382$) or workplace (Wilks' Lambda = 0.842, $p = 0.223$). In contrast, the results revealed statistically significant differences attributed to age (Wilks' Lambda = 0.512, $p < 0.001$) and years of experience (Wilks' Lambda = 0.600, $p < 0.001$).

Table (4.15): MANOVA Results for Differences in Pharmacists' Attitudes According to Demographic Characteristic

Source of Variance	Dependent Variable	Type III Sum of Squares	Degree of Freedom df	Mean Square	F- value	p-value
Intercept	Awareness	343.501	1	343.501	1138.791	.000
	Attitudes	384.321	1	384.321	999.024	.000
	Confidence	410.931	1	410.931	1067.383	.000
	Impact	400.142	1	400.142	1087.103	.000
	Benefit	419.244	1	419.244	802.198	.000
	Challenges	432.839	1	432.839	1107.303	.000
	Willingness	418.867	1	418.867	1275.593	.000
	Institutional	403.482	1	403.482	846.505	.000
Gender	Awareness	1.190	1	1.190	3.946	0.051
	Attitudes	1.060	1	1.060	2.755	0.102
	Confidence	0.958	1	.958	2.489	0.119
	Impact	0.922	1	.922	2.506	0.118
	Benefit	0.733	1	.733	1.403	0.241
	Challenges	0.247	1	.247	.631	0.430
	Willingness	0.163	1	.163	.497	0.483
	Institutional	0.069	1	.069	.145	0.705
Age	Awareness	9.235	2	4.618	15.309	**0.001***
	Attitudes	4.471	2	2.235	5.811	**0.005***
	Confidence	3.538	2	1.769	4.595	**0.014***
	Impact	7.253	2	3.626	9.852	**0.000***
	Benefit	3.409	2	1.704	3.261	**0.045***
	Challenges	1.735	2	.867	2.219	0.117
	Willingness	2.695	2	1.347	4.103	**0.021***
	Institutional	3.672	2	1.836	3.852	**0.026***
Experience	Awareness	1.621	1	1.621	5.375	**0.024***
	Attitudes	0.375	1	.375	.976	0.327
	Confidence	0.038	1	.038	.099	0.754
	Impact	0.084	1	.084	.228	0.635
	Benefit	0.433	1	.433	.829	0.366
	Challenges	0.080	1	.080	.206	0.652
	Willingness	1.609	1	1.609	4.899	**0.030***
	Institutional	2.893	1	2.893	6.070	**0.016***
Workplace	Awareness	0.743	1	.743	2.464	0.121
	Attitudes	0.631	1	.631	1.641	0.205
	Confidence	0.412	1	.412	1.071	0.305
	Impact	1.020	1	1.020	2.770	0.101
	Benefit	0.525	1	.525	1.004	0.320
	Challenges	0.147	1	.147	.375	0.542
	Willingness	0.009	1	.009	.029	0.866
	Institutional	0.055	1	.055	.115	0.735

***If the p-value is less than 0.05, the result is considered statistically significant.**

The results indicated that there were no statistically significant differences in pharmacists' awareness of AI and digital technologies, their attitudes toward AI in pharmacy practice, their confidence and readiness, their perceptions of the impact on the pharmacy profession, the benefits they perceive, the challenges they face, their willingness to adopt and use AI, or the institutional and environmental support they receive, based on gender ($p > 0.05$) or workplace ($p > 0.05$).

The results indicated that there were statistically significant differences in pharmacists' awareness of AI and digital technologies ($F= 5.38$, $p<0.05$), their willingness to adopt and use AI ($F= 4.90$, $p<0.05$), and the institutional and environmental support they receive ($F= 6.07$, $p<0.05$), attributed to years of experience. The arithmetic means and standard deviations of hospital pharmacists' perceptions of the application of modern technologies in pharmaceutical care services, attributable to differences in years of experience, are shown in Appendix C. These differences favored pharmacists with 6 years or more of experience.

According to Table 4.10, the results showed that there were a statistically significant differences in pharmacists' awareness of AI and digital technologies ($F= 15.31$, $p<0.05$), their attitudes toward AI in pharmacy practice ($F= 5.81$, $p<0.05$), their confidence and readiness ($F= 4.60$, $p<0.05$), their perceptions of the impact on the pharmacy profession ($F= 9.85$, $p<0.05$), the benefits they perceive ($F= 3.26$, $p<0.05$), their willingness to adopt and use AI ($F= 4.10$, $p<0.05$), or the institutional and environmental support they receive ($F= 3.85$, $p<0.05$), based on age. The arithmetic means and standard deviations of hospital pharmacists' perceptions of the application of modern technologies in pharmaceutical care services, attributed to age differences, are shown in Appendix C. To measure these differences Bonferroni post-test was employed, and the results are shown in the following Table.

Table (4.16) Bonferroni post-test to measure the differences attributed to age.

Variable	Categories of Age	1. Less than 30 Years	2. 30-39 Years	40 Years and above
Awareness of AI and digital technologies	**1**			0.897*
	2			1.19*
Attitudes toward AI in pharmacy practice	**2**			0.753*
Confidence and Readiness	**2**			0.753*
Perceptions of the impact on the pharmacy profession	**1**			0.689*
	2			0.977*
Benefits to perceive	**2**			0.688*
Willingness to adopt and use AI	**2**	0.345*		0.702*
Institutional and environmental support they receive	**2**	0.399*		0.768*

***Differences in arithmetic means between each age group based to Appendix C.**

The results from Table (4.16) showed that a statistically significant differences in pharmacists' awareness of AI and digital technologies, their attitudes toward AI in pharmacy practice, their confidence and readiness, their perceptions of the impact on the pharmacy profession, the benefits they perceive, their willingness to adopt and use AI, or the institutional and environmental support they receive based on age were between 30-39 years and 40 years and above in favor 30-39 years.

Chapter Five
Discussion of Findings and Recommendation

5.1 Discussion of the Levels of Awareness and Attitudes toward AI and Digital Technologies among Hospital Pharmacists

The results of the current research showed that hospital pharmacists had high levels of awareness and positive attitudes toward artificial intelligence technology in the health and pharmacy sectors. Generally, the participants were well acquainted with modern technologies in pharmacy practice and well-informed about their applications. They had a positive attitude toward AI's importance in enhancing pharmacy care. These results suggest that the pharmacy profession has a strong foundation in awareness and attitudes to support the application of AI technology in hospital pharmacy practice.

The degree of awareness and positive attitudes has not emerged by chance. The described levels of awareness and positive attitudes can instead be explained by the growing digitalization of healthcare systems and the increased application rates of pharmacy information systems, electronic prescriptions, and medication safety systems within the hospital setting. These trends were also reflected in international research, which indicated that familiarity of pharmacists with digital work processes appears to increase awareness and promote a positive attitude towards AI application system use (Benrimoh et al., 2023; Rowe et al., 2024; Raza et al., 2022). This is consistent with findings that indicate increased familiarity of individuals working within health environments with digital applications will promote increased acceptance of the utility of such applications within that domain (Waring et al., 2020).

The positive attitudes displayed by hospital pharmacists towards AI, especially with respect to the role of AI in the improvement of clinical decision-making and patient care, are not new and have been reflected by similar studies conducted previously. Hasan et al. (2024) showed that there is an overwhelming level of acceptance and eagerness amongst hospital pharmacists located in Jordan and surrounding countries towards the integration of AI within pharmacy practice, even though they have not been formalized in AI-related education on pharmacy practice. Such levels of acceptance of AI within pharmacy practice are reflected by similar attitudes towards AI by Syed et al. (2023).

Additionally, the current study's results explicitly indicate that hospital pharmacists are aware of the relevance of the AI technology to the pharmacy profession and are receptive to it, hence supporting the adoption of the technology. This result parallels the more general result in the pharmacy and health field of high awareness and positive attitudes towards readiness to adopt new technology innovations (Alalwan et al., 2017).

Nevertheless, the results also reflect broader international trends with regard to pharmacy as a profession, with the digital revolution emerging as an increasingly important factor with regard to professional practice and attitudes. Tele pharmacy, artificial intelligence-based decision support systems, and increased research into the role and scope of pharmacy as a profession, has all shown that pharmacists with general knowledge about technological advancements are generally more supportive with regard to professional growth and innovation (Poudel & Nissen, 2016; Alexander et al., 2021; Obaid et al., 2022). In this context, this has again been reflected by Jarab et al. (2023) and Abu Hammour et al. (2023), whereby increased familiarity with digital technology among pharmacists has contributed to increased acceptance with regard to artificial intelligence technology.

The present study offers its contribution to this body of evidence by confirming that there are a strong awareness and positive attitude amongst the pharmacists in the hospital regarding AI and technological aspects that correspond to the same level of cognitive preparedness and acceptance. It is imperative that despite the strong awareness level and attitude, we utilize this as a foundation to ensure the implementation of AI in pharmacy.

5.2 Perceived Benefits and Challenges of AI Technologies in Pharmaceutical Practice

Results from this study revealed that hospital pharmacists were aware of the immense benefits that artificial intelligence could offer to pharmacy. At the same time, they were also aware of the harsh challenges associated with implementing these changes. In general, hospital pharmacists showed an understanding of how artificial intelligence should increase efficiency, simplify patient service delivery, augment patient safety, and emphasize patient-centered care. This indicates that these individuals do not look at this innovation just for the sake of it but are relatively optimistic about it too. The optimism they showed towards the benefits associated with artificial intelligence might be due to increased familiarity with a digitized healthcare setting. Similar findings have been documented to reflect that AI applications play a crucial part in increasing work flow efficiency, minimizing medication errors, and maximizing accuracy associated with pharmacotherapy (Raza et al., 2022; Benrimoh et al., 2023; Rowe et al., 2024). Studies evaluating the delivery of clinical pharmacology services have also documented that applications associated with AI services enhance a move from technical tasks to patient-centered decision-making among pharmacists (Waring et al., 2020; Awala & Olutimehin, 2024). It was hypothesized that findings from this study would collect data consistent with a technology acceptance model that suggests perceived usefulness influences attitudes associated with embracing innovative technology (Chuttur, 2018).

Despite these supposed benefits, there are also some challenges that have been recognized by pharmacists in the current study to possibly hinder the successful adoption of AI. These include a lack of training and organizational preparedness, resistance to organizational change, lack of organizational data protection, and a lack of clarity in the organizational regulatory context. These possibly impending barriers seem to be organizational in context but not people-centric. This implies that the pharmacists' willingness to adopt AI might be contingent on their organizational context. The current findings support the views presented in the literature on a current study assessing the integration of AI in pharmacy (Raza et al. 2022; Syed et al. 2023; Obaid et al. 2022). The lack of training and organizational preparedness emerged as a notable challenge in the adoption of AI in the Jordanian pharmaceutical field (Hasan et al. 2024; Jarab et al. 2023). Professional sentiments concerning organizational preparedness, organizational governance, and organizational information infrastructure have been recognized in a global study concerning the integration of AI in pharmacological practices and the medical field in general (Raza et al. 2022; Syed et al. 2023; Obaid et al. 2022). The concurrent perception of benefits and challenges suggests the pharmacists in the current study appreciate an informed view regarding the adoption of AI.

The present study contributes to the existing pool of knowledge by illustrating that the opportunities and challenges of AI technology are perceived by hospital pharmacists concurrently. Thus, it becomes important for the successful application of AI technology in pharmacy, as highlighted by the results of this study, to adopt an overall strategy with a focus on making professionals' perceptions about benefits an important component.

5.3 Degree of Adoption of AI Technologies in Pharmacy Practice among Hospital Pharmacists

The findings from this current research stressed that the level of confidence, preparedness, and willingness of the hospital pharmacists to utilize the AI technologies in the field of pharmacy is very high. On the whole, the hospital pharmacists were confident about the usage of the AI technologies, prepared to implement the technological advancements in their field, and willing to learn about the implementation of the AI technologies. This suggested that the level of AI technology adoption among the hospital pharmacists is extremely high. However, this level of confidence and preparedness is not unexpected; instead, it could be clarified by the growing awareness of the pharmacists about the digital technology, their positive perceptions regarding the AI technologies, and their awareness about its usage in the pharmacy field. These same findings have been obtained from other past studies, where the pharmacists and other healthcare professionals have been more prepared to implement the AI technologies if they felt that they could master the new technology (Hasan et al., 2024; Saeed et al., 2024). This consistently validated the assumptions related to the Technology Acceptance Model. It had been assumed that the perceptions regarding the ease of usage of the technology have a very significant impact on the predictions that people are more influenced by the acceptance or usage of the technology (Chuttur, 2018).

Moreover, besides their level of readiness, pharmacists in the current study showed a strong level of intention to adopt and use AI technology, including its implementation, recommendation, use for training, and investment. These findings suggest that pharmacists' adoption of AI technology is far beyond their readiness level because it included either support and/or recommendation for adoption. Similar conclusions were drawn by other studies around the world and on a geographical basis too because healthcare providers with a positive attitude and adequate readiness showed a strong behavioral intention to adopt AI technology (Raza et al., 2022; Syed et al., 2023; Awala & Olutimehin, 2024). This study contributes to the existing body of work by showing that hospital pharmacists in Amman have a high level of AI technology absorption, defined as the degree of readiness and willingness to apply AI technology. It can also be said that the hospital pharmacists in Amman have a high level of AI technology adoption, as evidenced by their confidence in it.

5.4 Institutional and Environmental Support and the Perceived Impact of AI on the Pharmacy Profession

The results of the current study showed that hospital pharmacists reported a high degree of institutional and environmental support for integrating AI technologies into pharmacy practice. The pharmacists believed that their respective hospitals support the adoption and application of digital technologies in health, that there are leadership support, motivation, and training, and that there is evidence of planning for AI adoption. All these elements seem to highlight a suitable environment for AI adoption. Perceptions of the presence of these supportive factors within the institution have not occurred by accident; instead, they can be explained by the increasing awareness of the importance of digital health and AI in the strategic plans of healthcare organizations, as they strive to enhance service delivery and outcomes. Other studies have found similar results, showing the significance of leadership commitment, training, and infrastructure support as important factors in the implementation of AI in pharmacies and healthcare organizations (Hasan et al., 2024; Obaid et al., 2022; Adaileh & Alshawawreh, 2021).

In this fashion, the results showed that hospital pharmacists felt the influence of artificial intelligence to be important to the profession of pharmacy. In general, the views of the pharmacist group demonstrated their awareness that artificial intelligence could be leveraged to improve their role in the healthcare setting, reduce medication errors, and improve healthcare, but also understood the evolving nature of their profession due to ongoing artificial intelligence changes. At the same time, the notion that future employment is expected to be influenced by artificial intelligence captures the nature of change that occurs as a result of technological progress and changes in the workforce. Both perceptions seem to demonstrate intelligent awareness about the implications of artificial intelligence on the profession, which not only seeks to capitalize on the opportunity but is also aware about what could happen to the workforce. Both perceptions were also found in studies conducted across the world, whereby all seem to understand the health benefits offered by artificial intelligence, but also worried about their profession (Raza et al., 2022; Rowe et al., 2024; Abu Hammour et al., 2023).

The present study adds to this stream of literature by illustrating the existence of a significant link between the two perceptions of support, that of the profession and the organization, and that they interact in a way that builds on each other. An organizational environment filled with motivation, support, and investment will positively encourage pharmacists to look at AI, not as a threat, but as a tool for improving professional impact. This finds support in the Diffusion of Innovations theory, whose underlying reasoning points out the significance of organizational concerns in the way innovations get diffused in organizations over a period of time (Rogers, 2003).

5.5 Relationships among Awareness, Attitudes, Perceived Benefits, Challenges, Readiness, Institutional Support, Perceived Impact, and Willingness to Adopt AI Technologies

Findings from the present study uncovered that all eight variables in the proposed research model were significantly interrelated: awareness, attitude, perceived benefit, perceived challenges, confidence and readiness, institutional and environmental support, perceived impact on the pharmacy profession, and intention to adopt and use artificial intelligence technology were all positively interrelated. This means that these variables form an interrelated whole, where enhancements in one area coexist with corresponding enhancements in other areas rather than being separate factors that influence adoption.

The positively linked outcomes of awareness, attitudes, perceived benefits, and willingness to accept AI underscore the crucial function of knowledge and understanding in influencing pharmacists' acceptance of AI technology. The more knowledgeable the pharmacists were about AI, the more likely they were to possess a positive attitude towards its benefits and be open to its adoption and use. The results of this study, to a certain extent, validate previous findings on a similar issue, as it was revealed that knowledge and its utility have been major considerations for adoption intention in the related field of pharmacy and healthcare environments (Syed et al., 2023). It must be noted that despite the presence of positive correlation coefficients for perceived challenges, these findings validate that knowledge about challenges related to implementation did not adversely affect adoption intention. Rather, those pharmacists displaying greater familiarity about training, infrastructure, and challenges related to regulatory aspects of AI technology were more prepared to adopt it. This was found to be similar to previous research findings that healthcare personnel possessing greater familiarity about innovative technology could efficiently use it in an enabling healthcare environment (Raza et al., 2022; Hasan et al., 2024). Thus, this study further validates previous evidence on healthcare technology adoption that adoption of AI technology by pharmacists working at hospitals was done through joint efforts by awareness, attitude, support, and familiarity with related challenges of implementing these new technologies.

5.6 Effect of Training in Artificial Intelligence and Digital Health on Pharmacists' Perceptions and Adoption Intentions

The findings from the current study revealed that the group of pharmacists and decision-makers who received training on AI or digital health demonstrated increased awareness, attitudes, confidence, and intentions towards using AI technology, which was reflected as having positive outcomes in comparison to the control group. This, therefore, suggests that training is crucial for increasing the preparedness levels of pharmacists towards using the AI technology, as it helps to clarify any uncertainties, as well as understand the implication of integrating the AI technology.

The results are consistent with the findings of many studies which have identified the significance of education and training for developing the acceptance of healthcare providers for the application of AI technology. Hasan et al. (2024), and Saeed et al. (2024), concluded that the pharmacists and students who received education about AI showed higher levels of awareness and positive attitudes toward the application of the technology, and Syed et al. (2023) also emphasized the role of education to develop positive perceptions and adoption behavior in the minds of the providers of health services. On similar lines, the study of Raza et al. (2022), identified that the providers of health services who received education showed more informed and balanced perceptions about the positive as well as the negative implications of the application of the AI technology.

5.7 Effect of Professional Experience and Age on Pharmacists' Perceptions and Adoption of AI Technologies

The findings from the proposed study indicated that professional experience had a positive impact on familiarity with artificial intelligence and digital technology, the intention to use digital technology, and perceived support from the institution and environment among pharmacists. This indicates that professional experience plays a crucial role in shaping the predisposition of pharmacists in adjusting to technological innovation. The findings from this proposed study support other studies, which indicated that the confidence, acceptance, and adoption of AI and digital health technologies among pharmacists with increased professional experience are higher (Hasan et al., 2024; Raza et al., 2022). Additionally, Obaid et al. (2022) indicated that experienced pharmacists are capable of taking control of themselves within the technological environment of the organization, which positively influenced levels of perceived support from the environment.

Additionally, significant age differences have been found by this study concerning the perceptions of pharmacists on AI technologies. Pharmacists between the ages of 30 and 39 years demonstrated an increased awareness and positive attitudes towards AI and/or digital technology. Also, they showed increased favorable perceptions on the readiness of AI, willingness to adopt AI, professional impact of AI, and support of environmental variables. This suggests that these pharmacists have the right amount of work experience and are tech-savvy.

These results are in line with past literature that has shown that intermediate-aged individuals have shown positive attitudes and adoption intentions toward digital innovations in the health care industry. Hasan et al. (2024) have shown that mid-career pharmacists showed higher adoption of AI-based technology compared to other stages of their career, and this is due to their high digital literacy and confidence in their competence, according to Syed et al. (2023). To summarize, this study adds on to existing literature in the field in that experience and age are crucial factors that need to be taken into account in shaping pharmacists' attitudes and adoption of AI technology. These elements highlight the need for the adaptation of particular training methodologies that focus on the career stages of pharmacists, as well as the use of senior pharmacists as an important influencer or adoption agent of AI technology in hospital pharmacy practice.

5.8 Conclusions

The findings from the current study indicate that hospital pharmacists exhibited high levels of awareness, positive attitudes, confidence, readiness, and willingness to accept and apply artificial intelligence and digital health technologies in pharmacy practice. The results also confirmed that both hospital pharmacists are aware of the expected impact of AI on pharmacy practice and believe there are great benefits associated with the implementation of AI in pharmacy practice, as well as considering that the potential problems may restrict its implementation. Moreover, all dimensions of AI adoption are positively correlated with one another at a statistically significant level.

These outcomes make it evident that the importance of AI implementation in pharmacy practice cannot be attributed solely to technological development, but also to its potential to improve clinical practice, patient-focused practice, and evidence-based practice. The outcomes have reinforced the view that, for AI implementation or integration, it is essential that, in addition to reading the individual, there is support from the institution. In short, this study emphasizes the need to adopt an organized approach to AI integration for implementation in hospital pharmacy practice.

The findings of this study indicate that hospital pharmacists in Amman operate in a context where support for adopting AI is rising and where they recognize AI as a driving force in a process of professional change. It would appear that such a combination of a supportive environment and a supportive profession provides a vital ingredient in securing a positive future role for artificial intelligence within pharmacy practice.

5.9 Recommendations

1. Integration of AI Education within Pharmacy Practice and Education: There is a need to ensure the integration of artificial intelligence and digital health education into pharmacy practice and postgraduate pharmacy education.
2. Strengthen Institutional & Leadership Support: The administration of the hospital should support innovation related to AI by devising plans for incorporating AI in

their hospital, thus paving a way for innovation through digital tools within the hospital.

3. Structured and Continuous Training: The workshops and training programs have to be scheduled to enhance the confidence levels, competencies, and readiness of the pharmacists to perform effectively using the AI tool.
4. Formulate Clear Policies and Regulatory Guidelines: There is a great need to have policies formulated by policymakers and professional organizations related to ethical matters, data privacy, and governance in light of the use of AI in pharmacy practice.
5. Invest in Digital Infrastructure

There has to be investment in financial and technical resources to ensure that there is infrastructure support at the hospital pharmacy level to implement AI.

6. Encouraging Interdisciplinary Collaboration: It is important to ensure there is a collaboration of pharmacists, information technology experts, and administrators to ensure AI is well integrated into the healthcare system.
7. AI Monitoring & Evaluation: The implemented AI should always be monitored to determine its effectiveness as an AI tool used in pharmacy practice.

5.10 Study Implications

- Policy and Program Development

The findings obtained from this study shall be applicable in formulating policies on a national and institutional level, focusing on the use of artificial intelligence, digital health, and pharmaceutical care in the revolutionization of the healthcare sector.

- Healthcare Practice

In healthcare and pharmacy management, the research findings can be useful to understand the level of readiness and attitude of pharmacists and, accordingly, shape healthcare policy regarding the adoption of artificial intelligence.

- Professional Development

This is an indication that pharmacists need training that concentrates on equipping them with skills and capabilities to act as leaders.

- Workforce Transformation

The paper emphasizes trends emerging with regard to the employment of pharmacists when AI technology is used in the health sector.

- Study and Evaluation

These findings shall provide insights for future research on the long-run outcome of the implementation of AI technology in terms of its cost-effectiveness and impact on patient safety and quality of care.

5.11 Strengths and Limitations

5.11.1 Study Strengths

This study adopted a theoretical and structured approach that was anchored on prevailing models of technology adoption and the Diffusion of Innovations theory, which enhances the general validity of the findings. Moreover, the adoption of a validated research instrument ensured that the findings are reliable. Additionally, this study focused on the multi-dimensional concept of AI adoption that provided significant insights regarding pharmacists' attitudes, readiness, and environment.

5.11.2 Study Limitations

The purposive approach with a relatively small sample limited the generalizability of the findings to hospital pharmacists in the wider Amman area, Jordan. The cross-sectional approach affected the ability to determine causality or to measure changes in perception over time. This study was subject to time constraints, which represented one of its limitations and affected the depth of data collection and analysis.

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Appendices

Appendices 1: Questionnaire

Dear Participant,

This questionnaire is part of a master's research study aiming to evaluate hospital pharmacists' perceptions, awareness, readiness, and attitudes toward the implementation of modern technologies (MTs), including Artificial Intelligence (AI), Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR), within pharmaceutical care services in Amman, Jordan.

Your participation is completely voluntary, and all responses will remain anonymous and confidential. The collected data will be used solely for academic and research purposes.

Please answer all questions honestly and thoroughly. There are no right or wrong answers. Most items are based on a 5-point Likert scale:

1 = Strongly Disagree | 2 = Disagree | 3 = Neutral | 4 = Agree | 5 = Strongly Agree

Section A: Demographic Information

Age:	**☐ Under 30 ☐ 30–39 ☐ 40–49 ☐ 50 and above**
Gender:	☐ Male ☐ Female ☐ Prefer not to say
Years of experience:	☐ 1–5 ☐ 6–10 ☐ 11–15 ☐ 16+
Educational level:	☐ Bachelor's ☐ Master's ☐ PharmD ☐ PhD
Workplace type:	☐ Public Hospital ☐ Private Hospital
Are you involved in decision-making processes at your workplace?	☐ Yes ☐ No
Job role:	☐ Clinical Pharmacist ☐ Administrative Pharmacist ☐ Informatics Pharmacist ☐
Have you received any training in AI or digital health?	☐ Yes ☐ No

Section 2: Awareness of AI and Digital Technologies

No.	Question	1Strongly Disagree	2Disagree	3Neutral	4Agree	5Strongly Agree
1	I am aware of various modern technologies (MTs) used in healthcare and pharmacy.	☐	☐	☐	☐	☐
2	I have encountered modern technologies (MTs) in my professional practice.	☐	☐	☐	☐	☐
3	I can differentiate between Artificial Intelligence (AI), Virtual Reality (VR), and Augmented Reality (AR).	☐	☐	☐	☐	☐
4	I understand how MTs function in prescription validation and drug interaction detection.	☐	☐	☐	☐	☐
5	I am familiar with pharmacy information systems and how they integrate with MTs.	☐	☐	☐	☐	☐

Section C: Section C: Attitudes Toward AI in Pharmacy Practice

No.	Question	1Strongly Disagree	2Disagree	3Neutral	4Agree	5Strongly Agree
1	Artificial Intelligence (AI) is essential for improving pharmaceutical care.	☐	☐	☐	☐	☐
2	I believe AI can help pharmacists make better clinical decisions.	☐	☐	☐	☐	☐
3	I am enthusiastic about using AI in pharmacy practice.	☐	☐	☐	☐	☐
4	I support the integration of AI in pharmacy training and education.	☐	☐	☐	☐	☐
5	I believe that using AI improves the efficiency and accuracy of pharmacy services.	☐	☐	☐	☐	☐

Section D: Confidence and Readiness

No.	Question	1Strongly Disagree	2Disagree	3Neutral	4Agree	5Strongly Agree
1	I feel confident in using Artificial Intelligence (AI) in pharmacy services.	☐	☐	☐	☐	☐
2	I am ready to use AI tools if proper training is provided.	☐	☐	☐	☐	☐
3	I believe I can quickly learn how to operate AI-based pharmacy systems.	☐	☐	☐	☐	☐
4	I am open to adapting my workflow to include AI applications.	☐	☐	☐	☐	☐
5	I feel supported in my workplace to experiment with new AI tools.	☐	☐	☐	☐	☐

Section E: Perceived Impact on the Pharmacy Profession

No.	Question	1Strongly Disagree	2Disagree	3Neutral	4Agree	5Strongly Agree
1	AI will enhance pharmacists' clinical roles rather than replace them.	☐	☐	☐	☐	☐
2	AI can reduce human errors in medication dispensing.	☐	☐	☐	☐	☐
3	The use of AI will allow pharmacists to focus more on patient care.	☐	☐	☐	☐	☐
4	AI might lead to fewer job opportunities for pharmacists in the future.	☐	☐	☐	☐	☐
5	The role of pharmacists will evolve through the continuous adoption of AI.	☐	☐	☐	☐	☐

Section F: Perceived Benefits

No.	Question	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
1	AI technologies increase efficiency and reduce workload.	☐	☐	☐	☐	☐
2	AI improves decision-making accuracy in pharmacy services.	☐	☐	☐	☐	☐
3	AI helps in detecting harmful drug interactions and contraindications.	☐	☐	☐	☐	☐
4	Modern technologies help provide better patient-centered care.	☐	☐	☐	☐	☐
5	AI systems provide data-driven insights for pharmaceutical interventions.	☐	☐	☐	☐	☐

Section G: Perceived Challenges

No.	Question	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
1	I lack sufficient training on using AI tools in pharmacy.	☐	☐	☐	☐	☐
2	Our hospital lacks the infrastructure to support AI implementation.	☐	☐	☐	☐	☐
3	There is resistance from senior staff regarding the use of AI.	☐	☐	☐	☐	☐
4	I fear patient data privacy breaches when using AI systems.	☐	☐	☐	☐	☐
5	Policies and regulations around AI use in pharmacy are unclear.	☐	☐	☐	☐	☐

Section H: Willingness to Adopt and Use

No.	Question	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
1	I am willing to integrate AI tools into my daily pharmacy work.	☐	☐	☐	☐	☐
2	I would recommend AI tools to colleagues in similar roles.	☐	☐	☐	☐	☐
3	I will participate in AI-related training if offered by the hospital.	☐	☐	☐	☐	☐
4	I am likely to support future investment in AI systems in my department.	☐	☐	☐	☐	☐
5	I believe AI should be included in pharmacy education and training programs.	☐	☐	☐	☐	☐

Section I: Institutional and Environmental Support

No.	Question	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
1	My hospital encourages the use of digital health technologies.	☐	☐	☐	☐	☐
2	There is a strategic plan for AI adoption in our pharmacy department.	☐	☐	☐	☐	☐
3	My hospital provides regular training or workshops on emerging technologies.	☐	☐	☐	☐	☐
4	Leadership is supportive of innovation in pharmaceutical care.	☐	☐	☐	☐	☐
5	There are funds available for digital health transformation projects.	☐	☐	☐	☐	☐

Appendices 2: Ethical Approval

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تعهد الالتزام بأخلاقيات البحث العلمي لجامعة الشرق الأوسط
لسنة 2025

أتعهد أنا الموقع أدناه، وأنا بكامل أهليتي القانونية، بأن ألتزم بسياسة أخلاقيات البحث العلمي لجامعة الشرق الأوسط، والقوانين والأنظمة والتعليمات الصادرة بموجبها كافة، وأي تعديلات تطرأ عليها، وأقرّ بأنني اطلعت على بنودها كافة، وإنني أتعهد بالالتزام بالأهداف والتشريعات الناظمة كافة، وتنفيذ الإجراءات المتعلقة بها، والالتزام بالأمانة العلمية، وإنني بموجب هذا التعهد أتحمل المسؤوليات كلها، بأنواعها الجزائية و/أو المدنية كافة، وأتعهد أن أؤدي أي التزامات تتحقق فيما إذا خالفت القوانين والأنظمة والتعليمات، وفي حال عدم صحة و/أو دقة البيانات التي قدمتها للجامعة، وإنني أسقط مسبقاً توجيه يمين كذب الإقرار، وعليه أوقع في هذا اليوم الموافق ٢٣ / ٧ / ٢٠٢٥ .

المقر بما فيه

الاسم : فرح سامي أحمد عوض

المسمى الوظيفي : علوم صيدلانية/ماجستير

الكلية : الصيدلة

التوقيع :

Appendices 3 Descriptive Statistics of hospital pharmacists' perceptions of the application of modern technologies in pharmaceutical care services in based on age

		Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Awareness	Under 30 year	3.9261	.56625	.08349	3.7579	4.0942
	30-39 year	4.2194	.46577	.08366	4.0485	4.3902
	40-49 year	3.0286	1.07349	.40574	2.0358	4.0214
	Total	3.9595	.65916	.07192	3.8165	4.1026
Attitudes	Under 30 year	3.9696	.66529	.09809	3.7720	4.1671
	30-39 year	4.2387	.49104	.08819	4.0586	4.4188
	40-49 year	3.4857	.82347	.31124	2.7241	4.2473
	Total	4.0286	.64762	.07066	3.8880	4.1691
Confidence	Under 30 year	4.0043	.63873	.09418	3.8147	4.1940
	30-39 year	4.2968	.51347	.09222	4.1084	4.4851
	40-49 year	3.5429	.74578	.28188	2.8531	4.2326
	Total	4.0738	.63381	.06915	3.9363	4.2114
Impact	Under 30 year	4.0609	.60497	.08920	3.8812	4.2405
	30-39 year	4.3484	.55849	.10031	4.1435	4.5532
	40-49 year	3.3714	.92685	.35032	2.5142	4.2286
	Total	4.1095	.66471	.07253	3.9653	4.2538
Benefit	Under 30 year	4.0522	.77681	.11453	3.8215	4.2829
	30-39 year	4.3742	.53601	.09627	4.1776	4.5708
	40-49 year	3.6857	.60945	.23035	3.1221	4.2494
	Total	4.1405	.70713	.07715	3.9870	4.2939
Challenges	Under 30 year	4.1087	.56049	.08264	3.9423	4.2751
	30-39 year	4.3032	.66708	.11981	4.0585	4.5479
	40-49 year	3.7143	.15736	.05948	3.5688	3.8598
	Total	4.1476	.59889	.06534	4.0177	4.2776
Willingness	Under 30 year	4.1000	.54447	.08028	3.9383	4.2617
	30-39 year	4.4452	.58129	.10440	4.2319	4.6584
	40-49 year	3.7429	.60788	.22976	3.1807	4.3051
	Total	4.1976	.59597	.06503	4.0683	4.3270
Institutional	Under 30 year	4.0261	.72616	.10707	3.8104	4.2417
	30-39 year	4.4258	.62980	.11312	4.1948	4.6568
	40-49 year	3.6571	.82231	.31080	2.8966	4.4177
	Total	4.1429	.73177	.07984	3.9841	4.3017

Descriptive Statistics of f hospital pharmacists' perceptions of the application of modern technologies in pharmaceutical care services based on experience years

		Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Awareness	1-5	3.9622	.72086	.11851	3.7218	4.2025
	6-10	3.9574	.61423	.08959	3.7771	4.1378
	Total	3.9595	.65916	.07192	3.8165	4.1026
Attitudes	1-5	4.0270	.68339	.11235	3.7992	4.2549
	6-10	4.0298	.62551	.09124	3.8461	4.2134
	Total	4.0286	.64762	.07066	3.8880	4.1691
Confidence	1-5	4.0486	.69347	.11401	3.8174	4.2799
	6-10	4.0936	.58955	.08599	3.9205	4.2667
	Total	4.0738	.63381	.06915	3.9363	4.2114
Impact	1-5	4.0811	.66074	.10862	3.8608	4.3014
	6-10	4.1319	.67409	.09833	3.9340	4.3298
	Total	4.1095	.66471	.07253	3.9653	4.2538
Benefit	1-5	4.0378	.88423	.14537	3.7430	4.3327
	6-10	4.2213	.52459	.07652	4.0673	4.3753
	Total	4.1405	.70713	.07715	3.9870	4.2939
Challenges	1-5	4.1189	.63151	.10382	3.9084	4.3295
	6-10	4.1702	.57782	.08428	4.0006	4.3399
	Total	4.1476	.59889	.06534	4.0177	4.2776
Willingness	1-5	4.0973	.65933	.10839	3.8775	4.3171
	6-10	4.2766	.53496	.07803	4.1195	4.4337
	Total	4.1976	.59597	.06503	4.0683	4.3270
Institutional	1-5	3.9459	.92454	.15199	3.6377	4.2542
	6-10	4.2979	.49144	.07168	4.1536	4.4422
	Total	4.1429	.73177	.07984	3.9841	4.3017

Appendices 4

Table 3.1: The results of Cronbach's alpha coefficient for the dimensions of the study instrument

Sub-Scale	Number of items	Cronbach's Alpha coefficients	The Degree
Awareness of AI and Digital Technologies	5	0.92	Very High Reliability
Attitudes Toward AI in Pharmacy Practice	5	0.92	Very High Reliability
Confidence and Readiness	5	0.95	Very High Reliability
Perceived Impact on the Pharmacy Profession	5	0.98	Very High Reliability
Perceived Benefits	5	0.90	Very High Reliability
Perceived Challenges	5	0.88	High Reliability
Willingness to Adopt and Use	5	0.98	Very High Reliability
Institutional and Environmental Support	5	0.98	Very High Reliability
Overall Scale	40	0.98	Very High Reliability

***All values were calculated using Cronbach's alpha equation.**